IFSA 2023

The 20th World Congress of
The International Fuzzy Systems Association

August 20 – 23, 2023
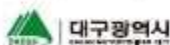EXCO, Daegu, Korea
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Sunday, August 20	
Room	**324**
18:00-20:00	**Welcome Reception**

Monday, August 21		
Room	**323 A**	**323 B**
09:00-10:20	**MA1** Fuzzy Systems, Uncertainty Modeling, Fuzzy Probability, and Statistics	**MB1** SS01: Robotic and Intelligent Systems-1
10:20-10:40	**Coffee Break** (Lobby)	
10:40-12:00	**MA2MB2** Fuzzy Systems: Decision-making, Inference Systems, SS01: Robotic and Intelligent Systems-	2 Preference Modeling, Optimization
12:00-13:00	**Lunch** (Food Court, 2F)	
13:00-13:20	**Sponsor Demonstration** RIAN (Room 324)	
13:20-13:30	**Opening Ceremony** (Room 324)	
13:30-14:30	**Plenary 1** Prof. Bernard De Baets (Ghent University, Belgium) (Room 324)	
14:40-16:00	**MA3** Fuzzy Control	**MB3** SS02: Intelligent Systems and Fuzzy Modeling-1
16:10-17:00	**Late Breaking Poster Session** with Coffee Break (Lobby)	**Invited Talk** Prof. Shahnaz Shahbazova (Room 324)
17:00-18:20	**MA4** Computational Intelligence in Information Systems	**MB4** SS02: Intelligent Systems and Fuzzy Modeling-2
19:00-22:00	**Daegu Night Tour**	

Tuesday, August 22		
Room	**323 A**	**323 B**
09:00-10:20	**TA1** Dynamical Modeling and Engineering Applications	**TB1** Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc
10:20-10:40	**Coffee Break** (Lobby)	
10:40-12:00	**TA2TB2** Data Analysis: Clustering, Associations Mining, SS03: Interval	Uncertainty Classification-1
12:00-13:20	**Lunch** (Food Court, 2F)	
13:20-15:00	**TA3TB3** Data Analysis: Clustering, Associations Mining, SS05: 2Application to Intelligent Systems for	High Performance Knowledge System and Its Classification-the Elderly
15:00-15:20	**Coffee Break** (Lobby)	
15:20-17:00	**TA4TB4** Deep learning, Machine learning, and AI-1SS06:	Maritime Intelligent Systems
17:30-21:00	**Plenary 2** President Kwang-Hyung Lee (KAIST, Korea) / (Room 324)	
	Banquet (Room 324)	

Wednesday, August 23		
Room	**323 A**	**323 B**
09:00-10:20	**WA1** Deep learning, Machine learning, and AI-2	**WB1** SS04: Forward Looking Decision-making under Uncertainty

10:20-10:40	Coffee Break (Lobby)	
10:40-12:00	**WA2** Deep learning, Machine learning, and AI etc	

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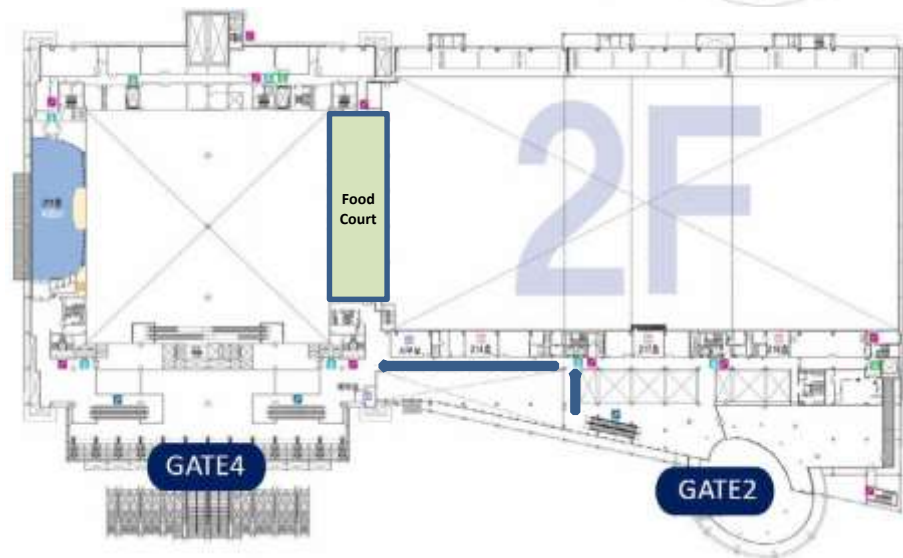
Floor Map

It is our great pleasure to welcome everyone to the 20th World Congress of the International Fuzzy Systems Association (IFSA 2023), held at EXCO, Daegu, Korea, which is one of the most beautiful cultural cities in Korea with a historical wealth of cultural and tourist attractions that is located in the south-eastern area of Korea.

The conference is an international forum for researchers and practitioners to share ideas in all aspects of fuzzy theory and its applications. The major goal of this conference is to bring together practitioners and scholars from all areas to discuss, demonstrate, and exchange research ideas within the scope of intelligence including fuzzy theory and its applications. To provide better opportunities to disseminate the research results presented at the conference, accepted papers will be published in the proceeding of IFSA 2023 and selected papers will be recommended to several prestigious journals for extended results.

IFSA 2023 will provide the opportunity for researchers to discuss their latest research results through several technical programs that consist of two plenary lectures, special organized sessions, and oral/poster sessions. In addition to the technical program, social events will offer the opportunities of strengthening networks and interactions between the participants of IFSA 2023.

We would like to express our sincere appreciation to the committee members for their valuable contributions to this conference. Also we would like to express many thanks to societies, institutes, and companies for their sponsorship.

Hope you have a wonderful and stimulating stay in Daegu, KOREA.

Sincerely,

Byung-Jae Choi
General Co-Chair of IFSA 2023 Daegu University, Korea

Frank Chung-Hoon Rhee
General Co-Chair of IFSA 2023 Hanyang University, Korea

Welcome Message

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Yeom (Chosun University, Korea)

Special Session Chairs
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Czeck Republic)

Local Arrangement Chairs
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General Information

Registration Desk

The registration desk on the main lobby (3F) in the venue will be open as follow:

Sunday, August 20, 2023   16:00-18:30 Monday, August 21, 2023   08:30-18:20 Tuesday, August 22, 2023   08:30-18:30
Wednesday, August 23, 2023   08:30-12:00

Wireless Internet Access

Wireless internet access will be available free of charge for all participants in the venue. Those wishing to use this wireless network are required to use their own laptops equipped with wireless LAN card.

Currency Exchange

Korea's currency unit is won which comes in 1,000, 5,000, 10,000 and 50,000 Won bills.
Most stores, hotels and restaurants in Korea will accept major international credit cards.
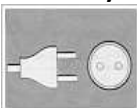
Tax & Tipping

Tipping is usually not customized in Korea, but it is appropriate for the excellent service. In major tourist hotels, 10% VAT and 10% service charge is added to the bills for rooms, meals and other services.

Climate

Average temperature of August in Daegu is 31ºC (87.8ºF).

Electricity

Korea uses 220 volts, 60 cycles system. Regarding the shape of outlet, Korea use 'Round pin attachment plug' type. Please check up your plug and prepare the adapter, if necessary.

Time Difference

In relation to Greenwich Mean Time, Korea is +9 hours.

Instructions for Presenter

Oral Session

The oral session room is equipped with a LCD projector and a Windows Laptop with PowerPoint and Acrobat PDF reader. Please do your best to use the room laptop and upload your PPT file on it before the beginning of the session. If you need to use your own laptop due to special reasons (only in case of requiring specific software for your presentation or in case of major compatibility problems), please check the connection with the projector before the session starts. Please arrive early enough to meet the session chair and to tell him/her your name, affiliation and the title of your paper before the session starts. The presentation time is 20 minutes. This includes speaker transition, setting up your computer (if needed), and

question & answers. So each speaker will have to finish his/her talk within 15~17 minutes to have enough time for question & answers.

Late Breaking Poster Session

Presenters are also responsible for mounting their own poster to the poster board prior to the opening of the poster session. All presenters must remain by their poster during the poster session.

A. Poster Specification

Posters must be designed to fit a 90cm wide x 150cm tall board. Posters may be prepared as a single poster or as several smaller sections (using A4 or letter sized papers) mounted together. The heading of the poster should list the paper title, author(s) name(s), and affiliation(s). The content of the poster should include introduction, related work, proposal, development/experimental results, and conclusion.

B. Poster Setup and Removal

Posters can be attached to the boards by push pins, which will be provided on-site. Posters must be set up by presenter at least 10 minutes before the poster session starts. Posters must be taken down by presenter right after the poster session is over. Posters not removed by 10 minutes after the session is over will be removed by staff.

Daegu Night Tour

IFSA2023 Organizing Committee is pleased to offer a Daegu Night Tour. The tour application should be done during the online registration process on the website.

- Time & Date: 19:00 - 22:00, Monday, August 21, 2023
- Free of Charge
- Gathering Spot: Main lobby (1F) of EXCO

Only first 40 people to apply will receive ticket.

Dinner is not served.

Tour Schedule

Time	Schedule
19:00-19:30	EXCO to Kim Gwang-seok Street
19:30-20:10	Kim Gwang-seok Street
20:10-20:30	To Suseong Lake
20:30-21:30	Fountain Show and Free time
21:30-22:00	Arrive at EXCO

Experience the best of Daegu with a tour of the iconic Kim Gwang-seok Street and the tranquil Suseong Lake.

Immerse yourself in the spirit of Kim Gwang-seok as you explore the vibrant streets dedicated to his legacy. Feel the emotions of his heartfelt music through art installations and live performances that capture the essence of his songs.

Escape the city bustle and find serenity at Suseong Lake. Walk along the peaceful shores, surrounded by lush greenery, and enjoy the calming atmosphere. Take a boat ride or have a relaxing picnic, immersing yourself in the natural beauty that Suseong Lake offers.

Join us on this unforgettable journey, where music and nature intertwine, showcasing the unique charm of Daegu.

Social Events

Apart from the technical programs, participants are also cordially invited to attend various social events, such as the welcome reception and banquet.

Welcome Reception

18:00-20:00, Sunday, August 20, 2023 Room
324 (3F), EXCO

The IFSA 2023 will welcome you at Welcome Reception. Meet some friends, have food & drink, and enjoy the summer night.

Banquet with Plenary Lecture

17:30-21:00, Tuesday, August 22, 2023 Room
324 (3F), EXCO

We hope this banquet will offer you a good opportunity to promote friendship with participants. Delicious food and great performance will be offered at the banquet. An invitation to the banquet is extended to the regular and student registrants. President Kwang-Hyung Lee's plenary lecture will be presented at the banquet.

Lunch

12:00-13:00, Monday, August 21, 2023
12:00-13:20, Tuesday, August 22, 2023
Food Court (2F), EXCO

The registration fee includes two lunches during the conference. Korean food buffet will be provided to attendees.

Plenary Speakers

13:30-14:30, Monday, August 21, 2023   Room 324 (3F)
Chair: Jung-Sik Jeong (Mokpo Maritime National University, Korea)

The Fascinating World of Transitivity

Bernard De Baets

Ghent University, Belgium

As a mathematician, I am fascinated with basic mathematical properties of functions and relations that may have a measurable impact in real applications. One such property is the transitivity of relations, the protagonist of my lecture. I will take a cursory glance at this property in various contrasting settings, including but not limited to: crisp versus fuzzy relations, binary versus ternary relations, fuzzy versus reciprocal relations, crisp versus stochastic transitivity. At the same time, I will discuss the role of transitivity in similarity measurement, preference modelling and aggregation theory, and, conversely, of aggregation theory in the study of transitivity. Moreover, I will point out some connections with preference structures, posets, lattices and trellises.

Biography
Bernard De Baets is a senior full professor in applied mathematics at Ghent University, Belgium, where he is leading the research unit KERMIT. As a trained mathematician, computer scientist and knowledge engineer, he has developed a passion for multi- and interdisciplinary research. Over the past 25 years, nearly 100 PhD students have graduated under his (co-)supervision. Bernard is a prolific writer, with a bibliography comprising over 650 peer-reviewed journal papers, accumulating more than 31000 Google Scholar citations (h-index 87). Several of his works have been bestowed upon with a best paper award. Moreover, he is a much-invited speaker, having delivered over 250 lectures world-wide. Bernard also actively serves the research community, in particular as co-editor-in-chief of Fuzzy Sets and Systems. Bernard has been an affiliated professor at the Anton de Kom Universiteit (Suriname); he is an Honorary Professor of Budapest Tech (Hungary), a Doctor Honoris Causa of the University of Turku (Finland), a Profesor Invitado of the Universidad Central "Marta Abreu" de las Villas (Cuba) and a Professor Extraordinarius of the University of South Africa. In 2011, he was elected Fellow of IFSA (International Fuzzy Systems Association) and, in 2012, he was a nominee for the Ghent University Prometheus Award for Research. In 2019, he received the EUSFLAT Scientific Excellence Award and in 2021 he was declared Honorary Member of the EUSFLAT Society.

Plenary Speakers (cont.)

Room 324 (3F)

17:30-18:00, Tuesday, August 22, 2023
Chair: Byung-Jae Choi (Daegu University, Korea)

Humanism 2.0 in AI era

Kwang-Hyung Lee
17th President of KAIST, Korea

We are already in the gate of AI era. Recently Chat GPT has shown how AI can be smart and how it can help human being's life. We have developed so many tools in our human history, but we have never felt about the tool we made. But now we human being feel some fears about AI because it's development speed is much higher than we imagine.

- Will AI replace our human being's jobs?
- Will AI dominate our human's life in the future?
- Will AI take the initiative of future civilization in the earth?

The appear of AI is the most significant civilizational event since we human being started to use the fire in the human history. We cannot stop the development of AI and AI will be much smarter in the future. Therefore, we need to think AI as a partner in the civilization and start to discuss a next humanism, that is Humanism 2.0 in the next century.

Biography
President Kwang Hyung Lee is a futurologist who pioneered multidisciplinary studies and research at KAIST. He advocated that the convergence of information, biology, and nanotechnologies would be critical for future industries, playing a crucial role in establishing the Department of Bio and Brain Engineering in 2001 and the Moon Soul Graduate School of Future Strategy in 2013. He then served as the inaugural head of both faculties.
President Lee has extensive administrative experience at KAIST, serving as Associate Vice President of the International Office, and Associate Vice President of Academic Affairs since early 2001. He also served as a member of the Korea Presidential Education Committee from 2020 to 2021, and is serving as a member of the Presidential Science Committee from 2023.
An ardent champion of entrepreneurship and startups, he has advised the first generations of KAIST startup entrepreneurs such as Nexon, IDIS, Neowiz, and Olaworks. President Lee, drawn to creative thinking and flipped learning, is famous for watching TV upside down. Such

pioneering ideas and his unusual thinking style were modeled in the 'eccentric professor' role featured on the TV hit drama of 'KAIST' from 1999 to 2000.

Plenary Speakers (cont.)

An alumnus who earned his MS in industrial engineering at KAIST in 1980 after completing his

undergraduate studies at Seoul National University, President Lee joined the KAIST faculty in 1985 upon receiving his PhD in computer science from INSA de Lyon in France.

A computer scientist as well as fuzzy theorist whose research area extends to AI, bioinformatics, fuzzy intelligent systems, and foresight methods, President Lee has published more than 70 papers in international journals and textbooks on system programming, fuzzy set theory and its applications, and three-dimensional creativity. He also invented a fuzzy elevator, subway operation controller, and AI transportation controller.

A fellow at the Korea Academy of Science and Technology and the National Academy of Engineering of Korea, he was decorated by the Korean government and the French government in recognition of the innovative education and research initiatives he has pursued

Invited Speaker

16:10-17:00, Monday, August 21, 2023   Room 324 (3F)
  Chair: Jin-Woo Jung (Dongguk University, Korea)

Lotfi A. Zadeh's Biography and Scientific Legacy: Soft Computing, Systems Theory, Decision, and Control

Prof. Shahnaz N. Shahbazova
Azerbaijan State University of Economics (UNEC), Azerbaijan

This paper describes Professor Lotfi A.Zadeh's life and his scientific legacy. The work begins with his birthplace, Baku, Azerbaijan, as well as his period of residence in Baku from birth until he was 10 years old. After that, he moved to Iran, where he lived until he turned 23 years old. Afterwards, he moved to the States for the purpose of getting an education. The paper also describes Studying and working in the States (Doctoral studies) and some information about

his Family. Zadeh's articles and the first results of scientific work, as well as Scientific discoveries (how the theory was born, the history of this theory, and its features), are described in this work too.

His collaborations with other scientists (his teacher Norbert Wiener, Rudolf Kalman, Charles A. Desoer, and others) are described in detail in this paper. The paper describes scientific life by years, from the last stage of life.

The paper also describes his visit to his country of origin, Azerbaijan, where he participated in the International Exhibition of Telecommunications and Information Technologies (BakuTel 2008), attended the reception of the President of Azerbaijan, and met with his close scientific friends.

This paper contains information for the five years that he was not with us. We have held two conferences: the 2018 7th World Conference on Soft Computing dedicated to the scientific activities of Professor Lotfi A. Zadeh and the 2022 8th and 8th World Conference on Soft Computing dedicated to the scientific activities and 100th anniversary birthday of Professor Lotfi A. Zadeh. We have published three books; two of them are selected papers from the 8th World conference on Soft Computing, and we dedicated one book within one year of his death. We will continue to work on his theories and ideas in the future, and we will continue to hold subsequent conferences dedicated to the scientific activities of Professor Zadeh.

Invited Speaker (cont.)

Biography

Dr. Shahnaz N. Shahbazova received the academic degree of PhD in 1995, the academic title of associate professor in 1996, and the academic degree of Doctor of Sciences in Engineering in 2015. Since 2002, she has been an academician and, since 2014, Vice-President of the Lotfi

A. Zadeh International Academy of Sciences. Since 2011, she has held the position of General Chairman and organizer of the World Conference on Soft Computing (WConSC), dedicated to the preservation and development of the scientific heritage of Professor Lotfi A. Zadeh. She is an honorary professor at the University of Obuda in Hungary and the "Aurel Vlaicu" University of Arad in Romania, and an Honorary Doctor of Philosophy of Technical Sciences at the UNESCO International Personnel Academy.

She is a member of the Board of Directors of the North American Society for Fuzzy Information Processing (NAFIPS); moderator of the Berkeley Soft Computing Initiative (BISC) group; member of the council 3338.01 "System Analysis, Management, and Information Processing" for the defense of PhD and doctoral dissertations, as well as chairman of the seminar of the same council at the Azerbaijan Technical University.

Dr. Shahbazova participated in many international conferences as an organizer, Honorary Chair, Session Chair, member of Steering, advisory, or International Program committees, and Keynote Speaker. She is president of the Fuzzy System Association in Baku.

She's received awards from India (3 months, 1998), Germany (DAAD, 3 months, 1999, 2003, 2010), the USA, California, and Berkeley University (Fulbright, 2007-2008, 2012, 2015, 2016,

2017). She is the author of more than 224 scientific articles, 8 methodological manuals, 9 textbooks, 3 monographs, and 9 books published by Springer. Her research interests include Artificial Intelligence, Soft Computing, Intelligent Systems, Machine Learning, Methods for Decision-Making, and Fuzzy Neural Networks.

Special Sessions

SS01: Robotic and Intelligent Systems

Ching-Chih Tsai (National Chung Hsing University, Taiwan)
Shun-Feng Su (National Taiwan University of Science and Technology, Taiwan)

In this special session, we intend to collect papers that reflect current progress in the Robotic and Intelligent Systems. We hope those papers can set a milestone for the Robotic and Intelligent Systems and also provide ideas for further exploration in this promising research area.

SS02: Intelligent Systems and Fuzzy Modeling

Jin-Tsong Jeng (National Formosa University, Taiwan)
Chen-Chia Chuang (National iLan University, Taiwan)

In this special session, we intend to collect papers that reflect current progress in the Intelligent Systems and Fuzzy Modeling. We hope those papers can set a milestone for the Intelligent Systems and Fuzzy Modeling and also provide ideas for further exploration in this promising research area.

SS03: Interval Uncertainty

Martine Ceberio (University of Texas at El Paso, USA)
Vladik Kreinovich (University of Texas at El Paso, USA)

Interval uncertainty is closely related to fuzzy techniques: indeed, if we want to know how the fuzzy uncertainty of the inputs propagates through the data processing algorithm, then the usual Zadeh's extension principle is equivalent to processing alpha-cuts (intervals) for each level alpha.

This relation between intervals and fuzzy computations is well known, but often, fuzzy researchers are unaware of the latest most efficient interval techniques and thus use outdated less efficient methods. One of the objectives of the proposed session is to help fuzzy community by explaining the latest interval techniques and to help interval community to better understand the related interval computation problems. Yet another

relation between interval and fuzzy techniques is that the traditional fuzzy techniques implicitly assume that experts can describe their degree of certainty in different statements by an exact number. In reality, it is more reasonable to expect experts to provide only a rage (interval) of possible values -- leading to interval-valued fuzzy techniques that, in effect, combine both types of uncertainty.

Special Sessions (cont.)

SS04: Forward Looking Decision-making under Uncertainty

Mikael Collan (LUT University, Finland)
Pasi Luukka (LUT University, Finland)

The session concentrates on supporting forward looking decision-making in the presence of uncertainty. The session is not "method specific". The decision-making support context is not and may include for example economic, health- and engineering related decisionmaking

SS05: High Performance Knowledge System and Its Application to Intelligent Systems for the Elderly

Jin-Woo Jung (Dongguk University, Korea)

This organized session aims at discussing the basic principles and methods of designing care systems for the elderly based on high performance knowledge engineering.
Topics of interest include, but are not limited to theory and application of:
- Machine/Deep learning and Artificial Intelligence for the elderly
- Action/Gesture Recognition for the elderly
- Internet of Things for the elderly
- Sensor networks/Intelligent sensors technology and application for the elderly
- Bioinformatics for the elderly
- Weakness/Secure Coding/Evaluation System/Vulnerability evaluation

SS06: Maritime Intelligent Systems

Joo Sung Kim (Mokpo National Maritime University)
Dong-Woo Kang (KRISO, Korea Research Institute of Ships and Ocean Engineering)

In this session, we present the state of art for the MIS(Maritme Intelligent Systems). Recently the maritme autonomous technologies have been applied for intelligent ship operation and magnagement. The deep learning and intelligent algorithms have also incorporated to realize the autonomous operation. We expect that the MIS session provides valuable and interesting discussions and presentations for the future promising research.

Sponsor Demonstration

Room 324 (3F)

13:00-13:20, Monday, August 21, 2023
Chair: In-Ho Ra (Kunsan National University, Korea)

Demonstrator

RIAN http://www.rian.kr

RIAN collects and analyzes high-quality learning data using YOLOv5 and artificial intelligence. We are a company that provides optimal data analysis solutions that accurately classify various data.

Presentation Schedule

MA1 Fuzzy Systems, Uncertainty Modeling, Fuzzy Probability, and Statistics

Monday, August 21, 09:00~09:40, Room 323A   Chair: Jin Hee Yoon (Sejong University, Korea)

MA1-1
(09:00 ~ 09:20)

Fuzzy Multiple Moderation and Moderated-Mediation Analysis
Beom Seok Kim, Kyung Jin Shin, Jin Hee Yoon (Sejong University, Korea)

MA1-2
(09:20 ~ 09:40)

Intervals Reflecting Inconsistency in Interval Scale Pairwise Comparison Matrix
Tomoe Entani (University of Hyogo, Japan)

MB1 - SS01: Robotic and Intelligent Systems-1

Monday, August 21, 09:00~10:20, Room 323B
Chair: Chun-Fei Hsu (National Ilan University, Taiwan)

MB1-1
(09:00 ~ 09:20)

Development of Evolutionary Simultaneous Localization and Mapping for Indoor Mobile Robots
Hsu-Chih Huang, Han-Lung Kuo (National Ilan University, Taiwan)

MB1-2
(09:20 ~ 09:40)

Adaptive Fractional-Order Sliding-Mode Motion Control Using Fuzzy-Neural LSTM-BLS for a Two-Wheeled Deformable Robot
Ching-Chih Tsai, Shih-Che Chen, Chi-Chih Hung, Yu-Kai Yang (National Chung Hsing University, Taiwan)

MB1-3
(09:40 ~ 10:00)

Trajectory Tracking Control Using RFBLS for Uncertain Tilting Quadrotors with Obstacle Avoidance
Ching-Chih Tsai, Adil-Hussain, Chun-Fu Mao, Chia-Wei Kuo (National Chung Hsing University, Taiwan), Kao-Shing Hwang (National Sun Yat-Sen University, Taiwan)

MB1-4
(10:00 ~ 10:20)

Command Filter-based Adaptive Prescribed Performance Asymptotic Tracking Control for Flexible-Joint Robots
Le Wang, Wei Sun (Liaocheng University, China), Shun-Feng Su (National Taiwan University of Science and technology, Taiwan)

MA2 - Fuzzy Systems: Decision-making, Inference Systems, Preference Modeling, Optimization

Monday, August 21, 10:40~12:00, Room 323A

Chair: Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-1
(10:40 ~ 11:00)

Effects of Complexity Enhancements on the Search Performance of Multiobjective Fuzzy Genetics-based Machine Learning
Takeru Konishi, Naoki Masuyama, Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-2
(11:00 ~ 11:20)

Federation Assisted Twin (FAT) Model for Edge Resource Management in Smart City over 6G Networks
Thiruvenkadam Srinivasan, M. Kowsalya (Vellore Institute of Technology, India), In-Ho Ra (Kunsan National University, Korea)

MA2-3
(11:20 ~ 11:40)

A Non-reciprocal Fuzzy Preference Modeling Method Based on Preference Disaggregation for Recommendation Systems
Zheng Wu, Huchang Liao (Sichuan University, China)

MA2-4
(11:40 ~ 12:00)

Some Notes on Monotone TSK Fuzzy Inference Systems
Yi Wen Kerk (Universiti Kebangsaan Malaysia, Malaysia), Kai Meng Tay (Universiti Malaysia Sarawak, Malaysia), Chee Peng Lim (Deakin University, Australia)

MB2 - SS01: Robotic and Intelligent Systems-2

Monday, August 21, 10:40~12:00, Room 323B

Chair: Hsu-Chih Huang (Tamkang University, Taiwan)

MB2-1
(10:40 ~ 11:00)

Decoupled Single-Input Fuzzy Control for a CMG Inverted Pendulum System
Bo-Wen Huang, Chun-Fei Hsu, You-Hao Xu, Tsu-Tian Lee (Tamkang University, Taiwan)

MB2-2
(11:00 ~ 11:20)

Swing-Up and Stabilization Controller Design for a Reaction Wheel Inverted Pendulum System via Self-Learning Fuzzy Control Approach
Zhi-Wen Lin, Tsu-Tian Lee, Chun-Fei Hsu, Bo-Wen Huang (Tamkang University, Taiwan)

MB2-3
(11:20 ~ 11:40)

Design of USV Positioning and Navigation in Unknown District based on
ChangMan Zou, WangSu Jeon, SangYong Rhee (Kyungnam University, Kore

MB2-4
(11:40 ~ 12:00)

Recurrent Fuzzy Broad Learning Controller for MIMO Nonlinear Digital TimeDelay Dynamic Systems
Ali Rospawan, Ching-Chih Tsai, Chi-Chih Hung, Shih-She Chen (National Chu Hsing University, Taiwan)

MA3 Fuzzy Control

Monday, August 21, 14:40~16:00, Room 323A

Chair: Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-1
(14:40 ~ 15:00)

A Controller based on a Class of Affine T-S Fuzzy Models
Conor O'Kane, Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-2
(15:00 ~ 15:20)

Switching Control Approach for Magnetic Levitation System
Kbrom Lbsu Gdey, Seong Woo Kwak (Pukyong National University, Korea)

MA3-3
(15:20 ~ 15:40)

AN INTELLIGENT METHOD FOR OPTIMIZING CALCULATIONS OF VISUAL AND AUDIO INFORMATION
Shahnaz N. Shahbazova (Azerbaijan State University of Economics, Azerba

MA3-4
(15:40 ~ 16:00)

Deep Fuzzy Hashing Network based on CIFAR-10 Dataset
Jon-Lark Kim, Byung-Sun Won (Sogang University, Korea), Youngjae Lim (DeepHelix Corp, Korea)

MB3 - SS02: Intelligent Systems and Fuzzy Modeling-1

Monday, August 21, 14:40~16:00, Room 323B

Chair: Chen-Chia Chuang (National Ilan University, Taiwan)

MB3-1
(14:40 ~ 15:00)

Intelligent Weighbridge Station Systems
Po-Sheng Chen, Chen-Chia Chuang, Tzu-Yun Lin (National Ilan University, Taiwan), Jin-Tsong Jeng (National Formosa University, Taiwan), Chih-Ching Hsiao (Kao Yuan University, Taiwan)

MB3-2
(15:00 ~ 15:20)

The Automatic Process to Generate a Takagi-Sugeno Fuzzy Model Controller
Bing-Gang Jhong, Mei-Yung Chen (National Taiwan Normal University, Taiwan), Shun-Feng Su (National Taiwan of Science and Technology University, Taiwan)

MB3-3
(15:20 ~ 15:40)

Base Stations Deployment with an Iterative Decreasing Candidate Algorithm in Internet of Things Systems
Zhen-Yin Lin, Jau-Yang Chang (National Formosa University, Taiwan), Hsu-Chih Huang (National Ilan University, Taiwan)

MB3-4
(15:40 ~ 16:00)

Interval Robust Granular Computing with City-block Distance Measure for Symbolic Data Analysis
Jin-Tsong Jeng, Nai-Cheng Shih (National Formosa University, Taiwan), Chen-Chia Chuang, (National Ilan University, Taiwan), Tsu-Tian Lee (Tamkang University, Taiwan)

LB-4

Which Fuzzy Implications Operations Are Polynomial? A Theorem Proves That This Can Be Determined by a Finite Set of Inequa
Sebastia Massanet (University of Balearic Islands, Spain), Olga Kosheleva, Kreinovich (University of Texas at El Paso, USA)

LB-5

How to Combine Probabilistic and Fuzzy Uncertainty: Theoretical Explanation of Clustering-Related Empirical Result
Laszlo Szilagyi (Sapientia University, Romania), Olga Kosheleva, Vladik Kreinovich (University of Texas at El Paso, USA)

LB-6   **Fuzzy Mathematics under Non-Minimal "And"-Operations (t-Norms):**

Equivalence leads to Metric, Order Leads to Kinematic Metric, Topology Leads to Area or Volume
Purbita Jana (India Institute of Technology Kanpur, India), Olga Kosheleva, Vladik Kreinovich (University of Texas at El Paso, USA)

LB-7   Software-defined Perimeter-based Segregated Network Systems
In-June Shin, Byung-Jae Choi, Chang Hone Kim (Daegu University, Korea)

LB-8   Toward a Consideration of Fuzziness in Implicit Hand Gestures
Dian Christy Silpani, Kaori Yoshida (Kyushu Institute of Technology, Japan)

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Late Breaking Poster Session
Monday, August 21, 16:10~17:00, Lobby

LB-1

Learning Procedure for Local Path Planning of Maritime Autonomous Surface Ships using Inverse Reinforcement Learning
Jae-Yong Lee, Ho Namgung, Joo-Sung Kim, Da-Un Jang (Mokpo National Maritime University, Korea)

LB-2

How to Propagate Interval (and Fuzzy) Uncertainty: Optimism-Pessimism Approach
Vinicius F. Wasques (Sao Paulo State University UNESP, Brazil), Olga Kosheleva, Vladik Kreinovich (University of Texas at El Paso, USA)

LB-3

How to Make Decision Under Interval Uncertainty: Description of All Reasonable Partial Orders on the Set of All Intervals
Tiago M. Costa (University de Tarapaca, Chile), Olga Kosheleva, Vladik Kreinovich (University of Texas at El Paso, USA)

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MA4 Computational Intelligence in Information Systems
Monday, August 21, 17:00~18:20, Room 323A
Chair: Marek Reformat (University of Alberta, Canada)

MA4-1
(17:00 ~ 17:20)

Assessing Uncertain Facts Against Fuzzy-based Knowledge Base using Evidence Theory

Marek Z. Reformat (University of Alberta, Canada), Ronald R. Yager (Iona College, USA)

MA4-2
(17:20 ~ 17:40)

Preference Rule Extraction with Kansei Retrieval Agent Using Fuzzy Reasoning for Music Retrieval

Hiroshi Takenouchi, Yuna Ishihara (Fukuoka Institute of Technology, Japan), Masataka Tokuamru (Kansai University, Japan)

MA4-3
(17:40 ~ 18:00)

Comparison of Quality-based and Quantity-based Real-time Rankings of Participants in Human-based Evolutionary Computation Systems

Hiroki Muta, Kei Ohnishi (Kyushu Institute of Technology, Japan)

MA4-4
(18:00 ~ 18:20)

Time Series Analysis for Insurance Data in R

Nahida Guliyeva (Ministry of Science and Education of the Republic of Azerbaijan, Azerbaijan), Hilala Jafarova (Azerbaijan State University of Economics, Azerbaijan)

MB4 - SS02: Intelligent Systems and Fuzzy Modeling-2

Monday, August 21, 17:00~18:20, Room 323B
Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-1
(17:00 ~ 17:20)

Design of Indoor Obstacle Avoidance Control with Monocular Visual Odometry

Rui-Qian Zhang, Chin-Wang Tao (National Ilan University, Taiwan), Chen Chiang, Sheng-En Lin, Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-2
(17:20 ~ 17:40)

Implementing Extreme Climate Reservoir Inflow Prediction based on Interval Type-2 Fuzzy Logic

Hao-Han Tsao, Yih-Guang Leu (National Taiwan Normal University, Taiwan)

MB4-3
(17:40 ~ 18:00)

Dynamic and Shared Resource Deployment using Graph Attention Technique

Sujitha Venkatapathy (Dr. N. G. P. Institute of Engineering and Technology, India), Thiruvenkadam Srinivasan (Vellore Institute of Technology, India), In-Ho Ra, Han-Gue Jo (Kunsan National University, Korea)

MB4-4
(18:00 ~ 18:20)

Enhancing Lung Disease Diagnosis via Semi-Supervised Machine Learning

Xiaoran Xu, Ravi Sankar (University of South Florida, USA), In-Ho Ra (Kunsan National University, Korea)

MB4-5
(18:20 ~ 18:40)

Comparative Analysis of Speech Features in the Aspect of Parkinson's Disease Classification Based on Machine Learning Methods

Ruchira Pratihar, Ravi Sankar (University of South Florida, USA), In-Ho Ra (Kunsan National University, Korea)

TA1 - Dynamical Modeling and Engineering Applications

Tuesday, August 22, 09:00~10:20, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

TA1-1 (09:00 ~ 09:20)	**Analysis of Chaotic Behaviors in Fuzzy Happiness Model with an External Force and Resilience considering Gaussian Noise** *Jin Hee Yoon (Sejong University, Korea), Youngchul Bae (Chonnam National University, Korea)*
TA1-2 (09:20 ~ 09:40)	**Fuzzy Based Power Sharing in Parallel Neutral Point Clamped Inverter for Microgrid Applications** *M. Kowsalya (Vellore Institute of Technology, India), Hyung-Jin Kim (Jeonbuk National University, Korea), In-Ho Ra (Kunsan National University, Korea)*
TA1-3 (09:40 ~ 10:00)	**Takagi-Sugeno Fuzzy Modelling of Electric Vehicle Steering System** *Hugang Han, Shinji Shigemaru (Prefectural University of Hiroshima, Japan), Miyu Shimizu (Shimane Johoshori Center Inc., Japan)*
TA1-4 (10:00 ~ 10:20)	**Mealy-type L-fuzzy Multiset Automata and Its Characterization** *Mallika Dhingra, M. K. Dubey (Manipal University Jaipur, India)*

TB1 - Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc

Tuesday, August 22, 09:00~10:20, Room 323B
Chair: Bart Kosko (University of Southern California, USA)

TB1-1 (09:00 ~ 09:20)	**Searching for Causal Phantom Nodes in Fuzzy Cognitive Maps** *Akash Kumar Panda, Bart Kosko (University of Southern California, USA)*
TB1-2 (09:20 ~ 09:40)	**A Fuzzy Transformer Network with Neuro-Fuzzy Loss for Phishing URL Detection** *Seok-Jun Bu, Sung-Bae Cho (Yonsei University, Korea)*
TB1-3 (09:40 ~ 10:00)	**On Quasi-intents in Complete Fuzzy Lattices** *Manuel Ojeda-Hernandez, Inma P. Cabrera, Pablo Cordero, Emilio MunozVelasco (Universidad de Malaga, Spain)*
TB1-4 (10:00 ~ 10:20)	**Stratified Multi-adjoint Normal Logic Programs** *M. Eugenia Cornejo, David Lobo, Jesús Medina (University of Cádiz, Spain)*

TA2 - Data Analysis: Clustering, Associations Mining, Classification-1

Tuesday, August 22, 10:40~11:40, Room 323A
Chair: Kwang Baek K m (Silla University, Korea)

TA2-1 (10:40 ~ 11:00)	**Robust Neuro-Fuzzy Inference in Dog Disease Pre-Diagnosis System for Casual Owners** *Kwang Baek Kim, Won Hee Son (Silla University, Korea), Yu Jeong Jeong, Gun Woong Lee (SAIZYE Co., Ltd, Korea), Doo Heon Song (Yong-In Art & Science University, Korea)*
TA2-2 (11:00 ~ 11:20)	**A Study on Synthetic Data Generation for Fall Detection** *Yeonwoo Choi, Bongjun Kim, Junho Jeong (Dongguk University, Korea)*
TA2-3 (11:20 ~ 11:40)	**Social Networks Analysis and Fuzzy Measures: a General Approach to Improve Community Detection in Directed Graphs** *Inmaculada Gutiérrez, María Barroso, Daniel Gómez, Javier Castro (Complutense University of Madrid, Spain)*

TB2 - SS03: Interval Uncertainty

Tuesday, August 22, 10:40~11:40, Room 323B
Chair: Vladik Kreinovich (University of Texas at El Paso, USA)

TB2-1 (10:40 ~ 11:00)	**Natural Color Interpretation of Interval-Valued Fuzzy Degrees** *Victor L. Timchenko (Admiral Makarov National Univ. of Shipbuilding, Ukraine), Yury P. Kondratenko (Petro Mohyla Black Sea National Univ., Ukraine), Vladik Kreinovich, Olga Kosheleva (Univ. of Texas at El Paso, USA)*
TB2-2 (11:00 ~ 11:20)	**Is Fully Explainable AI Even Possible: Fuzzy-Based Analysis** *Miroslav Svitek (Czech Techn. Univ. in Prague, Czech Republic), Olga Kosheleva, Vladik Kreinovich (Univ. of Texas at El Paso, USA)*
TB2-3 (11:20 ~ 11:40)	**Logical Inference Inevitably Appears: Fuzzy-Based Explanation** *Julio Urenda, Olga Kosheleva, Vladik Kreinovich (Univ. of Texas at El Paso, USA), Orsolya Csiszar (Aalen Univ. of Applied Sciences, Germany)*

TA3 - Data Analysis: Clustering, Associations Mining, Classification-2

Tuesday, August 22, 13:20~15:00, Room 323A
Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-1
(13:20 ~ 13:40)

Towards Interpreting Topic Models with ChatGPT

Emil Rijcken, Kalliopi Zervanou, Uzay Kaymak (Eindhoven University of Technology, The Netherlands), Floortje Scheepers (University Medical Centre Utrecht, The Netherlands), Marco Spruit (Leiden University, The Netherlands), Pablo Mosteiro (Utrecht University, The Netherlands)

TA3-2
(13:40 ~ 14:00)

Revised Optimization Algorithm for Maximum-Margin Nearest Prototype Classifier

Yoshifumi Kusunoki, Tomoharu Nakashima (Osaka Metropolitan Univ., Japan)

TA3-3
(14:00 ~ 14:20)

Evaluation of Bagging-type Ensemble Method Generating Virtual Data

Honoka Irie, Isao Hayashi (Kansai University, Japan)

TA3-4
(14:20 ~ 14:40)

Explainable Malware Detection Model through Dynamic Residual Kernel Generation

Mainak Basak, Myung-Mook Han (Gachon University, Korea)

TA3-5
(14:40 ~ 15:00)

A Study on the Creation of Improved 3D Models and Large-Scale Datasets Using NeRF

Min-Hong Park, Jae-Hoon Cho, Yong-Tae Kim (Hankyong National Univ., Korea)

TB3 - SS05: High Performance Knowledge System and Its Application to Intelligent Systems for the Elderly
Tuesday, August 22, 13:20~15:00, Room 323B
Chair: Jin-Woo Jung (Dongguk University, Korea)

TA4 - Deep learning, Machine learning, and AI-1
Tuesday, August 22, 15:20~17:00, Room 323A
Chair: Keon Myung lee (Chungbuk National University, Korea)

TA4-1
(15:20 ~ 15:40)

An Image Transformation-based Time Series Prediction Method

Sun Woo Jeong, Keon Myung Lee (Chungbuk National University, Korea)

TA4-2
(15:40 ~ 16:00)

Basic Application and Methodologies used for Sentiment Analysis: A Survey

Dayal Aakanksha, Kounen Fathima, Ali Athar, Hee-Cheol Kim (Inje University, Korea)

TA4-3
(16:00 ~ 16:20)

Lymph Node Metastasis Prediction in Gastric Cancer Using Clinical Feature Variables and Machine Learning

Tagne Poupi Theodore, Abdullah, Sikandar Ali, Hee-Cheol Kim (Inje University, Korea)

TA4-4
(16:20 ~ 16:40)

Dexterous Hand-Object Grasp Control With Prosthetic Hand

Sanghun Kim, Jiho Park, Jihie Kim, Hyeryung Jang (Dongguk University, Korea), Zhongqun Zhang, Hyung Jin Chang (University of Birmingham, UK)

TA4-5
(16:40 ~ 17:00)

Non-Contact Material Recognition from a Test-bench Using Reflected Sound Waves and Machine Learning

Min-Hyun Kim, Joongeun Jung (MoveAWheeL, Inc., Korea)

TB4 - SS06: Maritime Intelligent Systems
Tuesday, August 22, 15:20~16:40, Room 323B

Chair: Joo-Sung Kim (Mokpo National Maritime University, Korea)

WA1 - Deep learning, Machine learning, and AI-2
Wednesday, August 23, 09:00~10:20, Room 323A
Chair: Young-Jae Ryoo (Mokpo National University, Korea)

WA1-1
(09:00 ~ 09:20)

PERFORMANCE OF DEEPLABV3 WITH DIFFERENT BACKBONES ON SWEET PEPPER DATASET
Truong Thi Huong Giang, Young-Jae Ryoo (Mokpo National University, Korea)

WA1-2
(09:20 ~ 09:40)

Optimizing Fuzzy Fingerprints from Large Pre-Trained Models using Genetic Algorithms
Rui Ribeiro, Luisa Coheur, Joao P. Carvalho (INESC-ID, Portugal), Rui Jorge Almeida (Maastricht University, The Netherlands)

WA1-3
(09:40 ~ 10:00)

Cervical Spine Fracture Segmentation Using U-Net
Yaseen Muhammad, Abdullah, Ali Maisam, Ali Sikandar, Hee Cheol Kim (Inje University, Korea), Kwang Baek Kim (Silla University, Korea)

WA1-4
(10:00 ~ 10:20)

Prediction of Chronic Kidney Disease Using Machine Learning
Md Nayeem Hosen, Md Ariful Islam Mozumder, Rashedul Islam Sumon, HeeCheol Kim (Inje University, Korea)

WB1 - SS04: Forward Looking Decision-making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B
Chair: Pasi Luukka (LUT University, Finland)

WB1-1
(09:00 ~ 09:20)

Fuzzy Entropy and Similarity Based Feature Selection with Relevancy, Redundancy and Complementarity Information *Pasi Luukka (LUT University, Finland)*

WB1-2
(09:20 ~ 09:40)

Enhancing Fuzzy k-nearest Neighbor with Entropy-weighted Minkowski Distance and Local Means
Mahinda Mailagaha Kumbure, Pasi Luukka (LUT University, Finland)

WB1-3
(09:40 ~ 10:00)

On the Connection between the Generalized Dissemblance Index and Centers of Gravity of Triangular-type Fuzzy Numbers
Jan Stoklasa, Pasi Luukka, Jana Stoklasová (LUT University, Finland)

WB1-4
(10:00 ~ 10:20)

Extracting Business-relevance from Highly Imprecise Fuzzy Estimates
Mikael Collan, Pasi Luukka (LUT University, Finland), Jani Kinnunen (Åbo Akade University, Finland)

TB3-1
(13:20 ~ 13:40)

Deep Learning-based Human Activity Recognition using Dilated CNN and LSTM on UCF-50 Video Dataset
Bakht Alam Khan, Kwon Si Yeon, Jin-Woo Jung (Dongguk University, Korea)

TB3-2
(13:40 ~ 14:00)

Development of a User-friendly Interface for a Smart Home System based on IoT Technology
Chifuyu Matsumoto, Yuka Sone, Jinseok Woo, Yasuhiro Ohyama (Tokyo University of Technology, Japan)

TB3-3
(14:00 ~ 14:20)

Developing a Transformer based model for Extracting Relations Between Rare Diseases and Disabilities from Documents
Atif Latif, Jihie Kim (Dongguk University, Korea)

TB3-4
(14:20 ~ 14:40)

CT-Based Airway Segmentation Using a Hybrid Level-set and Growing Seed Technique
Nnubia Pascal Nnamdi, MinSuh Seo, Jinkyung Park, Yunsik Son (Dongguk University, Korea)

TB3-5
(14:40 ~ 15:00)

3D Dataset Generation for Airway Segmentation in Chest CT Imaging Based on Color Analysis and Double Threshold Setting Algorithm
MinSuh Seo, Nnubia Pascal Nnamdi, SeungHyun Woo, Hyeon-Jin Jeon, Yunsik Son (Dongguk University, Korea)

TB4-1
(15:20 ~ 15:40)

Development of Ship's Route Planning Method and Risk Assessment in Vessel Traffic Services Areas
Da-Un Jang, Joo-Sung Kim, Jung-Sik Jeong, Ho Namgung (Mokpo National Maritime University, Korea)

TB4-2
(15:40 ~ 16:00)

Prediction of Anchor Dragging Risk for Ship at Anchor Using Machine Learning on Imbalanced Data
Shem Otoi Onyango, Kwang Il-Kim, Sang-Lok Yoo (Jeju National University, Korea)

TB4-3
(16:00 ~ 16:20)

The Method of Semantic Segmentation Improvement using RescueNet based PSPNet
Habibullaev Sobirjon, Young Sil Lee (Dongseo University, Korea)

TB4-4
(16:20 ~ 16:40)

Estimation of Floating Debris Volume in an Estuary using U-Net
Dongwoo Kang, Sung Won Cho, Seung Hyun Lee (Korea Research Institute of Ships and Ocean Engineering, Korea), Jung Sik Jeong (Mokpo National Maritime University, Korea)

WB1-5
(10:20 ~ 10:40)

Promoting Stability using Ensemble Feature Selection with Evolutionary and Swarm Intelligence Algorithms

Christoph Lohrmann, Alena Lohrmann, Mahinda Mailagaha Kumbure, Pasi Luukka (LUT University, Finland), Yuri Lawryshyn (University of Toronto, Canada)

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WA2 - Deep learning, Machine learning, and AI etc
Wednesday, August 23, 10:40~12:00, Room 323A
Chair: Fernando Gomide (University of Campinas, Brazil)

WA2-1
(10:40 ~ 11:00)

Level Set Fuzzy Regression and Machine Learning

Fernando Gomide (University of Campinas, Brazil), Ronald Yager (Iona College, USA)

WA2-2
(11:00 ~ 11:20)

A Study of Processing Speed Index Prediction in Children with ADHD using Serious Game-Based Machine Learning

Jun-Su Kim, Jeong-Heon Song, Byeong-Il Kim, Hyun-Suk Lee (Woorisoft Inc, Korea), Byung-Jae Choi (Daegu University, Korea)

WA2-3
(11:20 ~ 11:40)

Survey on Recent Trends of Deep Learning-based Lane Detection Methods

Yun Hak Lee, Yeon Jeong Chae, Sung In Cho (Dongguk University, Korea)

WA2-4
(11:40 ~ 12:00)

Eigenvalue Distribution of Large Matrices with Randomness for Principal Component Analysis

Masaaki Ida (National Institution for Academic Degrees and Quality Enhancement of Higher Education, Japan)

3
3

Abstract

Monday
August 21, 2023

MA1 Fuzzy Systems, Uncertainty Modeling, Fuzzy Probability, and Statistics
Monday, August 21, 09:00~09:40, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

MA1-1   **Fuzzy Multiple Moderation and Moderated-Mediation Analysis**
(09:00 ~ 09:20)   *Beom Seok Kim, Kyung Jin Shin, Jin Hee Yoon (Sejong University, Korea)*

Keywords: Fuzzy multiple moderation, Fuzzy moderated moderated-mediation, Fuzzy least squares estimation, Fuzzy T-test

Mechanisms that become more complicated nowadays are explained better by models with multiple moderators than a simple model. Although expressing vague data by crisp numbers can increase the possibility of missing information, most of the analysis of the models above have been conducted with crisp numbers instead of fuzzy numbers so far. In this paper, we newly define fuzzy multiple moderators analysis (FMMA) that contains analysis of multiple moderation model and moderatedmediation model. In FMMA, values with ambiguity were transformed to triangular fuzzy numbers and we estimate regression coefficients with fuzzy least squares estimation. In addition, fuzzy T-test is proposed to judge whether the coefficient is significant, and fuzzy F-test and fuzzy R^2 are suggested as model evaluation indicators. They are compared with original version of classical multiple moderator analysis (CMMA).

MA1 Fuzzy Systems, Uncertainty Modeling, Fuzzy Probability, and Statistics
Monday, August 21, 09:00~09:40, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

MA1-2
(09:20 ~ 09:40)

Intervals Reflecting Inconsistency in Interval Scale Pairwise Comparison Matrix
Tomoe Entani (University of Hyogo, Japan)

Index Terms: interval analysis, MACBETH, inconsistency, pairwise comparison matrix

Measuring attractiveness by a categorical based evaluation technique (MACBETH) is an approach to help a decision maker quantify the relative attractiveness of an element using semantic judgments on the differences in the attractiveness of elements. A decision maker compares a pair of elements' attractiveness, so one element has multiple comparisons by comparing to all the others. The elements' attractiveness scores are obtained from the given pairwise comparison matrix, where comparisons are interval scales. This study focuses on the inconsistency among the given comparisons, often removed or corrected in the conventional MACBETH. We assume that a decision maker perceives a range of evaluations in her mind instead of a precise evaluation. In other words, she uses a crisp value within the element's interval score for each comparison so that the used crisp values depend on the elements to which it is compared. Therefore, we denote the element's attractiveness as an interval. We propose the problem of deriving the interval scores of elements from the given pairwise comparison matrix with an interval scale. In multi-criteria decision aiding (MDCA), the alternatives are assessed concerning multiple criteria. By the proposed problem, we have the interval priority scores of criteria and interval local scores of alternatives from the given pairwise comparison matrices. Then, we obtain the interval overall scores of alternatives by aggregating the interval scores. As for the priority weights of criteria, we propose the problem of determining them from the possibilistic view. Hence, they differ in alternatives and each bound of an interval overall score.

MB1 SS01: Robotic and Intelligent Systems-1
Monday, August 21, 09:00~10:20, Room 323B
Chair: Chun-Fei Hsu (National Ilan University, Taiwan)

MB1-1
(09:00 ~ 09:20)

Development of Evolutionary Simultaneous Localization and Mapping for Indoor Mobile Robots
Hsu-Chih Huang, Han-Lung Kuo (National Ilan University, Taiwan)

Keywords: Evolutionary, SLAM, Particle swarm optimization

This paper contributes to the development of evolutionary simultaneous localization and mapping (SLAM) for indoor mobile robots. An evolutionary particle swarm optimization (PSO) algorithm is incorporated with normal distributions transform (NDT) to address the SLAM problem of mobile robots. The robot operating system (ROS) was utilized to implement the evolutionary PSO-NDT SLAM system. Simulations were conducted to illustrate the efficiency and superiority of the proposed PSONDT SLAM method.

MB1 SS01: Robotic and Intelligent Systems-1
Monday, August 21, 09:00~10:20, Room 323B
Chair: Chun-Fei Hsu (National Ilan University, Taiwan)

MB1-2 Adaptive Fractional-Order Sliding-Mode Motion Control Using Fuzzy-Neural (09:20 ~ 09:40) **LSTM-BLS for a Two-Wheeled Deformable Robot**

Ching-Chih Tsai, Shih-Che Chen, Chi-Chih Hung, Yu-Kai Yang (National Chung Hsing University, Taiwan)

Keywords: Broad learning system (BLS), fractional-order sliding mode control, fuzzy long and shortterm memory neural network (FNLSTM), Two-wheeled deformable robot, two-wheeled steering (2WS).

This paper presents an adaptive sliding-mode fractional-order motion control using fuzzy long and short-term memory neural network (FNLSTM) together with broad learning system (BLS) for system design and trajectory tracking control of a two-wheeled deformable robot (TWDR). The mathematical models of the robot are derived for its two operational modes. An adaptive fractionalorder sliding-mode control together with FNLSTM-BLS is proposed to accomplish trajectory tracking of the TWDR. Numerical simulations and experimental results are conducted to show the effectiveness and superiority of the proposed control method in both operational modes to achieve trajectory tracking by comparing to some existing methods.

MB1 SS01: Robotic and Intelligent Systems-1
Monday, August 21, 09:00~10:20, Room 323B
Chair: Chun-Fei Hsu (National Ilan University, Taiwan)

MB1-3 Trajectory Tracking Control Using RFBLS for Uncertain Tilting Quadrotors with (09:40 ~ 10:00) **Obstacle Avoidance**

Ching-Chih Tsai, Adil-Hussain, Chun-Fu Mao, Chia-Wei Kuo (National Chung Hsing University, Taiwan), Kao-Shing Hwang (National Sun Yat-Sen University, Taiwan)

Keywords: Adaptive backstepping, sliding mode, quaternion, tilted quadrotor, recurrent fuzzy broad learning system (RFBLS), regulation, and trajectory tracking.

This paper presents a trajectory tracking control strategy with obstacle avoidance for a class of uncertain tilting quadrotors utilizing a recurrent fuzzy broad learning system (RFBLS). Each uncertain tilting quadrotor's dynamic behavior is modeled using quaternion-based matrix differential equations with two uncertain components caused by mass changes and unmolded dynamics. Via adaptive backstepping sliding mode control and online learning of the system uncertainties via RFBLS, a novel adaptive trajectory tracking control law is presented to achieve three-dimensional flight trajectory tracking in the presence of uncertainties using adaptive backstepping and online learning of system uncertainties via RFBLS. A new obstacle avoidance approach is proposed to prevent any collisions from any static and dynamic obstacles. Four simulations are conducted to show the effectiveness and merits of the proposed method.

MB1 SS01: Robotic and Intelligent Systems-1
Monday, August 21, 09:00~10:20, Room 323B
Chair: Chun-Fei Hsu (National Ilan University, Taiwan)

MB1-4
(10:00 ~ 10:20)

Command Filter-based Adaptive Prescribed Performance Asymptotic Tracking Control for Flexible-Joint Robots
Le Wang, Wei Sun (Liaocheng University, China), Shun-Feng Su (National Taiwan University of Science and technology, Taiwan)

Index Terms: Flexible-joint robots, adaptive backstepping control, asymptotic tracking, prescribed performance

This study reports the adaptive asymptotic tracking control problem for flexible-joint robot systems, the output tracking error can be kept within the prescribed range, as time approaches infinity, the asymptotic tracking result can be obtained. The prescribed performance function and the positive integrable time-varying function are introduced simultaneously in the control design of flexible-joint robot systems for the first time. The control scheme is designed under the frame of adaptive backstepping method and command filtered technique, which successfully avoids the problem of complexity explosion. Finally, the feasibility of the proposed scheme is proved by the simulation

MA2 - Fuzzy Systems: Decision-making, Inference Systems, Preference Modeling, Optimization
Monday, August 21, 10:40~12:00, Room 323A
Chair: Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-1
(10:40 ~ 11:00)

Effects of Complexity Enhancements on the Search Performance of Multiobjective Fuzzy Genetics-based Machine Learning
Takeru Konishi, Naoki Masuyama, Yusuke Nojima (Osaka Metropolitan University, Japan)

Keywords: Fuzzy Classifier Design, Evolutionary Multiobjective Optimization, Complexity Enhancements

Multiobjective evolutionary fuzzy systems have actively been studied for more than two decades. Among them, Multiobjective Fuzzy Genetics-based Machine Learning (MoFGBML) can efficiently obtain a set of fuzzy classifiers, considering maximizing classification accuracy and minimizing model complexity. However, MoFGBML has a strong bias in the search process toward minimizing the complexity. Thus, it is difficult to obtain classifiers with high accuracy at the risk of complexity. In this paper, to mitigate the above bias, we examine the effects of two complexity enhancements on the search performance of MoFGBML. One is a rule merge operation that merges two rule sets from parent solutions into an offspring solution. The other is a two-stage framework, which first performs accuracy-oriented single-objective optimization, and then multi-objective optimization is performed.

MA2 - Fuzzy Systems: Decision-making, Inference Systems, Preference Modeling, Optimization
Monday, August 21, 10:40~12:00, Room 323A
Chair: Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-2

Federation Assisted Twin (FAT) Model for Edge Resource Management in (11:00 ~ 11:20) **Smart City over 6G Networks**
Thiruvenkadam Srinivasan, M. Kowsalya (Vellore Institute of Technology, India), In-Ho Ra (Kunsan National University, Korea)

Keywords: 6G, IoE, smart city, resource scheduling.

The widespread implementation of the Internet of Everything (IoE) in wireless networks with the assistance of edge devices has created a number of issues, including the need for performance monitoring and effective resource management. Millions of connected devices, including smartphones, terminals, wearable tech, automobiles, sensors, actuators, and applications, can operate smoothly at high data rates and low latency thanks to the mobile traffic enabled by 6G IoE. The methods currently in use might not have a reliable model for forecasting changes in the demands for services from various applications. In this work, Federation Assisted Twin (FAT) model is proposed to track all user requirements in an Internet of Everything system by connectivity and service delivery in order to enable seamless communication with intelligent resource provisioning for multiple applications.

MA2 - Fuzzy Systems: Decision-making, Inference Systems, Preference Modeling, Optimization
Monday, August 21, 10:40~12:00, Room 323A
Chair: Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-3
(11:20 ~ 11:40)

A Non-reciprocal Fuzzy Preference Modeling Method Based on Preference Disaggregation for Recommendation Systems
Zheng Wu, Huchang Liao (Sichuan University, China)

Keywords: Non-reciprocal fuzzy preference relation, Preference modeling, Preference disaggregation, Recommendation systems

A recommendation system is an algorithmic system that recommends items of interest to users based on their historical preferences. A common solution is to model user preferences regarding multiple

criteria and obtain a ranking of items for recommendation. Available preferences may be incomplete, and criteria may be conflicting, leading to potential incomparability between items. However, existing studies on recommendation disclaim the existence of incomparability in their formulation. Non-reciprocal fuzzy preference relation (NRFPR) is a preference format that can represent incomparability arising from incomplete preference elicitation, or aggregation between conflicting criteria. This paper investigates the preference modeling method based on NRFPRs. We improve the elicitation of an NRFPR by a two-parameter structure to increase feasibility in practice. To derive the values of parameters as well as criteria weights based on historical data, a multi-criteria preference disaggregation model is developed. In this way, user preferences are modeled, and the user's decision-making process can be repeatedly simulated for recommendation. A numerical example of hotel recommendation is given to show the feasibility and advantages of the proposed method for recommendation systems.

MA2 - Fuzzy Systems: Decision-making, Inference Systems, Preference Modeling, Optimization

Monday, August 21, 10:40~12:00, Room 323A
Chair: Yusuke Nojima (Osaka Metropolitan University, Japan)

MA2-4 **Some Notes on Monotone TSK Fuzzy Inference Systems**
(11:40 ~ 12:00)
Yi Wen Kerk (Universiti Kebangsaan Malaysia, Malaysia), Kai Meng Tay (Universiti Malaysia Sarawak, Malaysia), Chee Peng Lim (Deakin University, Australia)

Keywords: Fuzzy Inference Systems, Ordered Weighted Averaging, data-driven monotone Takagi-Sugeno-Kang fuzzy model

This article presents our recent research on monotone Takagi-Sugeno-Kang (TSK) Fuzzy inference systems (FISs). We outline a few remarks on the necessary and sufficient conditions for TSK-FIS to be monotone, building upon the Ordered Weighted Averaging (OWA) principle and the orness concept. Some remarks for constructing monotone TSK-FIS from monotone data, extended from our previous findings, are further elucidated.

MB2 SS01: Robotic and Intelligent Systems-2

Monday, August 21, 10:40~12:00, Room 323B
Chair: Hsu-Chih Huang (Tamkang University, Taiwan)

MB2-1 **Decoupled Single-Input Fuzzy Control for a CMG Inverted Pendulum** (10:40 ~ 11:00) **System**
Bo-Wen Huang, Chun-Fei Hsu, You-Hao Xu, Tsu-Tian Lee (Tamkang University, Taiwan)

Keywords: Fuzzy control, Balancing control, Control moment gyroscope, Inverted pendulum system

The control moment gyroscope (CMG) inverted pendulum system consists of a rotating disk and one or more gimbal motors that tilt the angular momentum of the rotating disk. Its control objective is to stabilize the inverted pendulum in its upright position and keep it controlled there, and it is now widely used for research and advanced educational purposes. Unfortunately, the CMG inverted pendulum system is a nonlinear, unstable, and underactuation dynamic system. To attack this problem, this study proposes a decoupled single-input fuzzy control (DSFC) method to stabilize the inverted pendulum. Firstly, the CMG inverted pendulum system is decoupled into two second-order subsystems: one is body roll subsystem and the other is gyroscope pitch subsystem. Secondly, a decoupled sliding surface (DSS) is developed to condition its main target from the secondary target, where it includes all information of the body roll angle and gyroscope pitch angle of the CMG inverted pendulum system. Then, the information from the DSS is used to control both of body roll angle and gyroscope pitch angle drive to zeros, simultaneously. Finally, an 8-bits microcontroller (Arduino Mega 2560) is used to implement the DSFC method. The performance of the proposed DSFC scheme is verified by real-time experiments showing the robustness to time-varying uncertainties and external disturbances of the CMG inverted pendulum.

MB2 SS01: Robotic and Intelligent Systems-2
Monday, August 21, 10:40~12:00, Room 323B
Chair: Hsu-Chih Huang (Tamkang University, Taiwan)

MB2-2 **Swing-Up and Stabilization Controller Design for a Reaction Wheel Inverted** (11:00 ~
11:20) **Pendulum System via Self-Learning Fuzzy Control Approach**
Zhi-Wen Lin, Tsu-Tian Lee, Chun-Fei Hsu, Bo-Wen Huang (Tamkang University,
Taiwan)

Keywords: Fuzzy control, Rule modifier, Swing-up control, Stabilization control, Reaction wheel
pendulum.

In this study, a reaction wheel inverted pendulum (RWIP) shaped like a Reuleaux triangle is designed,
requiring consideration of the swing-up and stabilization control strategies. For the swing-up control
strategy, a swing-up controller is proposed to swing up the pendulum to its upright position. For the
stabilization control strategy, a stabilization controller, which is comprised of a speed controller and
a selflearning fuzzy controller (SLFC), is proposed to control it at the upward unstable equilibrium
point. The SLFC contains two fuzzy systems: one is the fuzzy controller and the other is the rule
modifier. The rule modifier gives a tuning value to modify the fuzzy rule of fuzzy controller based on
the fuzzy firing weight. Meanwhile, a sliding-mode approach is used to effectively reduce the number
of fuzzy rules and also improve the control performance in the presence of system uncertainties and
external disturbances. Finally, the experimental results show that not only the swing-up controller
allows the pendulum to be swung quickly to a position near its upright position but also the
stabilization controller system allows the pendulum to be control at the upright position after SLFC
parameter learning.

MB2 SS01: Robotic and Intelligent Systems-2
Monday, August 21, 10:40~12:00, Room 323B
Chair: Hsu-Chih Huang (Tamkang University, Taiwan)

MB2-3 **Design of USV Positioning and Navigation in Unknown District based on DQN**
(11:20 ~ 11:40) *ChangMan Zou, WangSu Jeon, SangYong Rhee (Kyungnam University, Korea)*

Keywords: Data fusion; DQN; Shore baseline extraction; USV;

In order to solve the problem of surface unmanned vehicle (USV) positioning and navigation when
GPS is limited, this paper combines Lidar `scan images and satellite images to jointly construct
environmental waters images with shore baselines, which provides a feasible solution for USV Area
and path. At the same time, design a control system based on Deep Q-learning Network (DQN), first
conduct learning training and testing in a fixed water environment, continuously adjust its network
parameters, and optimize the relevant data set in its experience pool. The trained system also has

certain obstacle avoidance capabilities. Finally, the USV system designed based on this paper has been
tested in different water environments and compared with other control algorithms. The test results
show that it has strong self-learning ability and adaptability to unfamiliar water environments. It has
a great auxiliary effect on the resource development of unknown waters.

MB2 SS01: Robotic and Intelligent Systems-2
Monday, August 21, 10:40~12:00, Room 323B
Chair: Hsu-Chih Huang (Tamkang University, Taiwan)

MB2-4   **Recurrent Fuzzy Broad Learning Controller for MIMO Nonlinear Digital**
(11:40 ~ 12:00)   **TimeDelay Dynamic Systems**
                  Ali Rospawan, Ching-Chih Tsai, Chi-Chih Hung, Shih-She Chen (National Chung
                  Hsing University, Taiwan)

Keywords: Intelligent control, MIMO controller, nonlinear control, recurrent fuzzy broad learning system, setpoint tracking

This paper presents a recurrent fuzzy broad learning controller (RFBLC) to improve its robust setpoint tracking and also achieve noise reduction and disturbance rejection for a class of multi-input multioutput (MIMO) digital nonlinear discrete-time time-delay dynamic systems.The parameters of the newly control method, dubbed as MIMO-RFBLC, are online updated using the deepest gradientdecent approach, and its closed-loop stability is investgated to propose a sufficient condition to select the range of a leaning rate. Two comparative simulations are conducted to show effectiveness and superiority of the proposed MIMO-RFBLC in comparison with existing adaptive PID controllers.
The proposed method would provide useful references for professionals working in this area.

MA3 Fuzzy Control
Monday, August 21, 14:40~16:00, Room 323A
Chair: Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-1   **A Controller based on a Class of Affine T-S Fuzzy Models**
(14:40 ~ 15:00)   *Conor O'Kane, Hugang Han (Prefectural University of Hiroshima, Japan)*

Index Terms: Affine T-S fuzzy model, partition, piece-wise Lyapunov function, LMIs, S-procedure

What is first made clear in this paper, is that when designing a controller based on an affine T-S fuzzy model, the resulting LMIs to determine parameters pertinent to the controller are innately infeasible. However, the feasibility of the LMIs can be increased by the introduction of quadratic inequalities with certain properties. To meet this end, this paper partitions the state space into cells based on the information of the antecedents of fuzzy rules, such that the system dynamics can be focused on each of the cells. In fact, it is the cells away from the origin that possess the desired quadratic inequalities. Finally, a piece-wise controller is proposed on the basis of this partition in an effort to increase the feasibility of the final LMIs.

MA3 Fuzzy Control

Monday, August 21, 14:40~16:00, Room 323A
Chair: Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-2	**Switching Control Approach for Magnetic Levitation System**
(15:00 ~ 15:20)	*Kbrom Lbsu Gdey, Seong Woo Kwak (Pukyong National University, Korea)*

Keywords: Magnetic Levitation System, non-linear system, Switching Control, sliding mode, Jacobean linearization

Magnetic levitation system (Maglev) is a nonlinear system that attracts the attention of many researchers, especially control engineers. It has wide range of application such as robotics, highspeed transportation, and many more. Unfortunately, it is not a simple task to control it, due to its high nonlinear characteristics. Hence, a control engineer has the responsibility to make this system easily controllable, thus, we are going to apply a new controller called switching control using sliding mode and Jacobean Linearization targeted to regulate the position of a magnetic-ball in Maglev. In this research paper, A nonlinear behavior model representation for Magnetic Levitation (Maglev) System is designed initially using MATLAB/Simulink as a modelling method. Finally, the results and simulation verify that the proposed controller succeed to stabilize the system, with the desired value of the performance specification parameters, i.e. with < 1 second of rising time, < 2 seconds of settling time, zero overshoot, and without steady state error.

MA3 Fuzzy Control

Monday, August 21, 14:40~16:00, Room 323A
Chair: Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-3	**AN INTELLIGENT METHOD FOR OPTIMIZING CALCULATIONS**
(15:20 ~ 15:40)	**OF VISUAL AND AUDIO INFORMATION**
	Shahnaz N. Shahbazova (Azerbaijan State University of Economics, Azerbaijan)

Keywords: recognizing visual information, recognizing sound information, semantic concept, isolating information objects, disassembling a visual scene, method of algorithmic parallelization, algorithmic model of the functioning

In this paper, the main methods are considered, which are the result of an experimental search for the most stable solutions capable of solving the problem of recognizing visual and audio information in the natural environment. The paper analyzes the effect of the negative impact of studying the details of objects, which on the one hand significantly (up to 10 times) increases the computational load and, on the other hand, practically does not affect the success of recognition. Often, such studies are harmful until the object itself's belonging to a particular semantic concept is precisely established.

MA3 Fuzzy Control
Monday, August 21, 14:40~16:00, Room 323A
Chair: Hugang Han (Prefectural University of Hiroshima, Japan)

MA3-4   **Deep Fuzzy Hashing Network based on CIFAR 10 Dataset**
(15:40 ~ 16:00)   *Jon-Lark Kim, Byung-Sun Won (Sogang University, Korea), Youngjae Lim*
(DeepHelix Corp, Korea)

Keywords: Deep neural network (DNN), Fuzzy neural network (FNN), Hashing learning, Image retrieval

This paper proposes a new hashing method called deep fuzzy hashing network (DFHN) [1]. DFHN combines fuzzy logic techniques with DNNs to learn more effective binary codes that can model uncertainties in the data using fuzzy rules. The concept of generalized Hamming distance, derived from fuzzy logic theory, is introduced to model the outputs of convolutional and fully connected layers in DFHN. This distance is computed efficiently through an XOR square operation on the inputs and weights. Experiments conducted on large-scale image dataset, CIFAR-10, demonstrate that DFHN achieves competitive retrieval accuracy while maintaining efficient training speed compared to state-of-the-art deep hashing approaches.

MB3 SS02: Intelligent Systems and Fuzzy Modeling-1
Monday, August 21, 14:40~16:00, Room 323B
Chair: Chen-Chia Chuang (National Ilan University, Taiwan)

MB3-1   **Intelligent Weighbridge Station Systems**
(14:40 ~ 15:00)   *Po-Sheng Chen, Chen-Chia Chuang, Tzu-Yun Lin (National Ilan University,*
Taiwan), Jin-Tsong Jeng (National Formosa University, Taiwan), Chih-Ching

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Hsiao (Kao Yuan University, Taiwan)

Keywords: Intelligent weighbridge station, YOLO, Image measurement

Because "oversized vehicles" and "vehicles carrying dangerous goods" will cause serious injuries if they are not careful on the highway, the weighbridge station at the entrance of the highway is an important gate for maintaining the safety of the tunnels. In general, the Lidar technology is used to describe the exterior of the vehicle and obtain the length, width, and height of the vehicle. However, LIDAR sometimes cannot obtain correct vehicle information in complex operating environments. In this study, an intelligent weighbridge station system is proposed. In this system, YOLOv3 and image

processing techniques are used for the identification of vehicles carrying dangerous goods, image capture of approved weight on the side of the vehicle, and ultra-scale identification such as ultralong, ultra-wide, and ultra-high. This system can solve the problem that the current weighbridge station is difficult to visually verify the weight of the side of the large truck and the problem of low efficiency in identifying the length, width, and height of the vehicle. It also assists the law enforcement basis for the current law enforcement unit at the weighbridge station to make a bill and report, to provide a reference for subsequent safety judgments and violation detection for vehicles driving on roads.

MB3 SS02: Intelligent Systems and Fuzzy Modeling-1
Monday, August 21, 14:40~16:00, Room 323B
Chair: Chen-Chia Chuang (National Ilan University, Taiwan)

MB3-2   **The Automatic Process to Generate a Takagi Sugeno Fuzzy Model Controller**
(15:00 ~ 15:20)   *Bing-Gang Jhong, Mei-Yung Chen (National Taiwan Normal University, Taiwan),*
Shun-Feng Su (National Taiwan of Science and Technology University, Taiwan)

Keywords: Takagi-Sugeno fuzzy model controller, MATLAB Symbolic Math Toolbox, linear matrix inequality, parallel distributed compensation

Takagi-Sugeno(T-S) fuzzy model control is a powerful and useful method for a nonlinear system, but the process to generate a T-S fuzzy model is usually case-by-case and time-consuming. In this paper, we automatize this process with MATLAB Symbolic Math Toolbox to generate a controller automatically and almost immediately. Moreover, the necessity of the symbolic toolbox is no longer required after the controller is generated. In actual use, there is no difference between the automatically generated T-S fuzzy model controller and general controllers. The simulation results show that the performance of the proposed controller is much better than a traditional fuzzy controller. Therefore, the proposed method has advantages in rapid deployment.

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MB3 SS02: Intelligent Systems and Fuzzy Modeling-1
Monday, August 21, 14:40~16:00, Room 323B
Chair: Chen-Chia Chuang (National Ilan University, Taiwan)

MB3-3   **Base Stations Deployment with an Iterative Decreasing Candidate Algorithm in** (15:20 ~
15:40)   **Internet of Things Systems**
Zhen-Yin Lin, Jau-Yang Chang (National Formosa University, Taiwan), Hsu-Chih
Huang (National Ilan University, Taiwan)

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Keywords: Base station (BS), Coverage ratio, Deployment budget, Internet of Things (IoT), Sensor Devices (SDs), voting

Due to technological advancements in Internet of Things (IoT) systems, sensor devices (SDs) are able to collect and transmit data more effectively in harsher environments. However, the Base Station (BS) is unable to fully cover all of the SDs when the number of SDs continues to increase. Based on the concept of multi-round voting, we propose a high-coverage and low-cost BS deployment strategy. Simulation results demonstrate that our proposed deployment algorithm achieves maximum coverage ratio of SDs and minimum deployment budget of BSs in IoT systems.

Late Breaking Poster Session

Monday, August 21, 16:10~17:00, Lobby

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MB3 SS02: Intelligent Systems and Fuzzy Modeling-1
Monday, August 21, 14:40~16:00, Room 323B
Chair: Chen-Chia Chuang (National Ilan University, Taiwan)

MB3-4
(15:40 ~ 16:00)

Interval Robust Granular Computing with City block Distance Measure for Symbolic Data Analysis
Jin-Tsong Jeng, Nai-Cheng Shih (National Formosa University, Taiwan), ChenChia Chuang, (National Ilan University, Taiwan), Tsu-Tian Lee (Tamkang University, Taiwan)

Keywords: Granular computing, Interval robust granular computing, Noise and outliers, Symbolic data analysis.

Clustering algorithms have been widely used in data analysis for computer science, deep learning and artificial intelligence. At present, data format in the clustering analysis has changed from singlevalued data to symbolic data. Hence, how to deal with symbolic data become very important? In this paper, we proposed interval robust granular computing for improving clustering problem on symbolic data analysis. In general, Witold granular computing clustering easily handled the symbolic data. However, if we consider the symbolic data that included noise and outliers, the Witold granular computing clustering will be effected via noise and outliers on the performance. Hence, we proposed robust granular computing approach that used different distance measure approaches and concept of determine annealing to improve granular clustering on symbolic data analysis. From the experimental results, we can verify the results of our proposed method that can deal with interval data with noise and outliers for granular computing on symbolic data analysis.

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LB-1

Learning Procedure for Local Path Planning of Maritime Autonomous Surface Ships using Inverse Reinforcement Learning
Jae-Yong Lee, Ho Namgung, Joo-Sung Kim, Da-Un Jang (Mokpo National Maritime University, Korea)

Keywords: Maritime autonomous surface ships, Scenario, Reinforcement Learning, Inverse Reinforcement Learning

Existing research with the maritime autonomous surface ships (MASS) attempted to develop algorithms based on various techniques used in robotics as well as the international regulations for preventing collision at the sea (COLREGs). However, in the event of complex encounter situations, it was difficult to quantify all of these situations with only if-then rule. Hence, the reinforcement learning (RL) was utilized for those problem. Nonetheless, the research using the RL for the MASS restricted collision avoidance action within the set scenario because of the reward function with considering only the navigation rules of the COLREGs. According to rule 2 of the COLRESs, it mentioned that the vessel may make a departure from the COLREGs rules necessary to avoid immediate danger. This study thus presents the learning procedure for the inverse reinforcement learning so that the MASS is able to obtain the reward function from navigator's knowledge in the event of complex encounter situations.

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Late Breaking Poster Session
Monday, August 21, 16:10~17:00

LB-2   **How to Propagate Interval (and Fuzzy) Uncertainty:**
Optimism-Pessimism Approach
Vinicius F. Wasques (Sao Paulo State University UNESP, Brazil), Olga Kosheleva,
Vladik Kreinovich (University of Texas at El Paso, USA)

Keywords: interval uncertainty, fuzzy uncertainty, uncertainty propagation, interactive addition of intervals

In many practical situations, inputs to a data processing algorithm are known with interval uncertainty, and we need to propagate this uncertainty through the algorithm, i.e., estimate the uncertainty of the result of data processing. Traditional interval computation techniques provide guaranteed estimates, but from the practical viewpoint, these bounds are too pessimistic: they take into account highly improbable worst-case situations when all the measurement and estimation errors happen to be strongly correlated. In this paper, we show that a natural idea of having more realistic estimates leads to the use of so-called interactive addition of intervals, techniques that has already been successful used to process interval uncertainty. Thus, we provide a new justification for these techniques. If we use a known interpretation of a fuzzy set as a nested family of intervals – its alpha-cuts – then we can naturally extend our results to the case is fuzzy uncertainty.

LB-3   **How to Make Decision Under Interval Uncertainty:**
Description of All Reasonable Partial Orders on the Set of All Intervals
Tiago M. Costa (University de Tarapaca, Chile), Olga Kosheleva, Vladik
Kreinovich (University of Texas at El Paso, USA)

Keywords: decision making, interval uncertainty, partial order, decision making under interval uncertainty

In many practical situations, we need to make a decision while for each alternative, we only know the corresponding value of the objective function with interval uncertainty. To help a decision maker in this situation, we need to know the (in general, partial) order on the set of all intervals that corresponds to the preferences of the decision maker. For this purpose, in this paper, we provide a description of all such partial orders – under some reasonable conditions. It turns out that each such order is characterized by two linear inequalities relating the endpoints of the corresponding intervals, and that all such orders form a 2-parametric family.

Monday, August 21, 16:10~17:00, Lobby

LB-4   **Which Fuzzy Implications Operations Are Polynomial?**
          A Theorem Proves That This Can Be Determined by a Finite Set of Inequalities
          Sebastia Massanet (University of Balearic Islands, Spain), Olga Kosheleva, Vladik
          Kreinovich (University of Texas at El Paso, USA)

Keywords: fuzzy logic, fuzzy operations, polynomial fuzzy operations, Tarski-Seidenberg theorem

To adequately represent human reasoning in a computer-based systems, it is desirable to select fuzzy operations that are as close to human reasoning as possible. In general, every real-valued function can be approximated, with any desired accuracy, by polynomials; it is therefore reasonable to use polynomial fuzzy operations as the appropriate approximations. We thus need to select, among all polynomial operations that satisfy corresponding properties – like associativity – the ones that best fit the empirical data. The challenge here is that properties like associativity mean satisfying infinitely many constraints (corresponding to infinitely many possible triples of values), while most effective optimization techniques assume that the number of equality or inequality constraints is finite. Thus, it is desirable to find, for each corresponding family of infinitely many constraints, an equivalent finite set of constraints. Such sets have been found for many fuzzy operations – e.g., for implication operations represented by polynomials of degree 4. In this paper, we show that such equivalent finite sets always exist, and we describe an algorithm for generating these sets.

LB-5   **How to Combine Probabilistic and Fuzzy Uncertainty:**
          Theoretical Explanation of Clustering-Related Empirical Result
          Laszlo Szilagyi (Sapientia University, Romania), Olga Kosheleva, Vladik
          Kreinovich (University of Texas at El Paso, USA)

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Keywords: fuzzy sets, clustering, fuzzy clustering, probabilistic clustering

In contrast to crisp clustering techniques that assign each object to a class, fuzzy clustering algorithms assign, to each object and to each class, a degree to which this object belongs to this class. In the most widely used fuzzy clustering algorithm – fuzzy c-means – for each object, degrees corresponding to different classes add up to 1. From this viewpoint, these degrees act as probabilities. There exist alternative fuzzy-based clustering techniques in which, in line with the general idea of the fuzzy set, the largest of the degrees is equal to 1. In some practical situations, the probability-type fuzzy clustering works better; in other situations, the more fuzzy-type technique leads to a more adequate clustering. It is therefore desirable to combine the two techniques, so that one of them will cover the situations where the other method does not work so well. Such combination methods have indeed been proposed. An empirical comparison has shown that out of all these combined methods, the most

effective one is the method in which we the use the product of probability and fuzzy degree. In this paper, we provide a theoretical explanation for this empirical result.

LB-6   **Fuzzy Mathematics under Non-Minimal "And"-Operations (t-Norms):**
          Equivalence leads to Metric, Order Leads to Kinematic Metric, Topology
          Leads to Area or Volume
          Purbita Jana (India Institute of Technology Kanpur, India), Olga Kosheleva,
          Vladik Kreinovich (University of Texas at El Paso, USA)

Keywords: fuzzy mathematics, equivalence relation, metric, order, kinematic metric, topology, area, volume

Most formulas analyzed in fuzzy mathematics assume – explicitly or implicitly – that the corresponding "and"-operation (t-norm is the simplest minimum operation. In this paper, we analyze what happens if instead, we use other "and"-operations. It turns out that for such operations, a fuzzification of a mathematical theory naturally leads to a more complex mathematical setting: fuzzification of equivalence relation leads to metric, fuzzification of order leads to kinematic metric, and fuzzification of topology leads to area or volume.

LB-7   **Software-defined Perimeter-based Segregated Network Systems**

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          In-June Shin, Byung-Jae Choi, Chang Hone Kim (Daegu University, Korea)

Keywords: Network segmentation, Network security, Software defined perimeter

Many companies protect their internal assets by logically or physically segmenting their network to limit access to their information and systems, and install VPNs to securely access internal network assets from the outside. However, the network segregation technique is a perimeter-based security method, and hackers can access data from the inside without any restrictions if they jump over one boundary, such as hacking or phishing emails. In this paper, I will explain why a Software Defined Perimeter (SDP)-based network segregation environment is necessary for traditional network segregation.

Late Breaking Poster Session

Monday, August 21, 16:10~17:00, Lobby

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Monday, August 21, 16:10~17:00, Lobby

LB-8   **Toward a Consideration of Fuzziness in Implicit Hand Gestures**

Dian Christy Silpani, Kaori Yoshida (Kyushu Institute of Technology, Japan)

Keywords: Hand Gesture, Fuzziness of Human Behavior, Human Implicit Attitude

The ability to engage with humans in a friendly and familiar manner is one of the main objectives in designing and constructing a system for human-machine or human-robot interaction. To achieve this type of engagement, a machine should understand its interest in the dialogue using natural and intuitive conversational functionality. From the robotics perspective, building embedded intelligent robots involves using natural processes, variety, and inheritance principles. Humans can study robot behavior like how they study other human behavior. In this study, we focus on investigating human communication as expected. The machine was intended to observe the individual, attempt to analyze the surrounding environment, and then try to seamlessly integrate into the conversation as we humans do rather than imitate the position. We proposed scenarios and new techniques by investigating and understanding human implicit hand gestures in natural conversation. Analyzing human-like concepts through human hand gestures is the challenge of this research since hand gestures vary widely, can be influenced by many factors, and have complicated meanings to interpret. Besides, from all these experiments, we conclude that one way to understand the fuzziness that comes from human data is to investigate the implicit attitude of human behavior.

MA4 - Computational Intelligence in Information Systems
Monday, August 21, 17:00~18:20, Room 323A
Chair: Marek Reformat (University of Alberta, Canada)

MA4-1   **Assessing Uncertain Facts Against Fuzzy-based Knowledge Base using Evidence** (17:00 ~ 17:20)   **Theory**

Marek Z. Reformat (University of Alberta, Canada), Ronald R. Yager (Iona College, USA)

Keywords: Evidence Theory, Uncertainty, RDF triples, Knowledge Base

Collecting information from multiple sources results in a knowledge base containing different and often contradictory facts. In many cases, these facts are equipped with degrees of certainty, representing beliefs in their correctness. Yet, an interesting problem arises when a new uncertain fact must be evaluated against such a knowledge base. This paper addresses the issue of assessing uncertain facts against a knowledge base by applying an evidencebased technique comparing the imprecise fact with the imprecise statement(s) from the base.

MA4 Computational Intelligence in Information Systems

Monday, August 21, 17:00~18:20, Room 323A
Chair: Marek Reformat (University of Alberta, Canada)

MA4-2   Preference Rule Extraction with Kansei Retrieval Agent Using Fuzzy Reasoning (17:20 ~
17:40)   **for Music Retrieval**

Hiroshi Takenouchi, Yuna Ishihara (Fukuoka Institute of Technology, Japan),
Masataka Tokuamru (Kansai University, Japan)

Keywords: Preference rule extraction, Fuzzy reasoning, Evolutionary computation

This paper proposes a music retrieval system with Kansei retrieval agent (KaRA) model using fuzzy reasoning, including "don't care" (DC) labels, for generating fuzzy rules. Our previous work generated fuzzy rules for understanding user preferences without DC labels. However, it was hard for both the system and users to understand the generated rules because of the great rule length and complicated interpretation. The system proposed herein uses DC labels in fuzzy rules for features that a user does not care about. In this study, we performed an evaluation experiment with real users and investigated system effectiveness from the viewpoint of user preference rule extraction. The experiment aimed to compare a system that uses DC labels (i.e., the proposed system) with another that does not use them. The results confirmed that both systems can retrieve user-preferred songs and generate user preference rules similarly.

MA4 - Computational Intelligence in Information Systems

Monday, August 21, 17:00~18:20, Room 323A

Chair: Marek Reformat (University of Alberta, Canada)

MA4-3   Comparison of Quality-based and Quantity-based Real-time Rankings of (17:40 ~
18:00)   **Participants in Human-based Evolutionary Computation Systems** *Hiroki Muta, Kei Ohnishi (Kyushu Institute of Technology, Japan)*

Keywords: Human-based evolutionary computation, quantity-based rankings, quality-based rankings

Human-based evolutionary computation is one type of evolutionary computation (EC) in which humans conduct fitness evaluations as well as evolutionary operators. In the paper we experimentally compare a humanbased EC system using a ranking method for participants based on the number of times of solution creation and evaluation and that using a ranking method for participants based on quality of solutions that the participants created and evaluated. The rankings are intended to motivate participants in human-based EC to contribute problem-solving. The quality of a solution is defined as the total sum of fitness values given to the solution by participants. The experimental results show that the ranking method based on quality reflects the contributions of participants to the rankings more appropriately and that it motivates them more highly.

MA4 Computational Intelligence in Information Systems
Monday, August 21, 17:00~18:20, Room 323A
Chair: Marek Reformat (University of Alberta, Canada)

MA4-4	Time Series Analysis for Insurance Data in R
(18:00 ~ 18:20)	*Nahida Guliyeva (Ministry of Science and Education of the Republic of Azerbaijan, Azerbaijan), Hilala Jafarova (Azerbaijan State University of Economics, Azerbaijan)*

Keywords: Time series, Autoregressive process, Forecasts, Autocorrelation, a summary of the model, Insurance data, R codes.

Insurance areas are important areas in the global financial economy. The negative effects of the pandemic didn't go unnoticed in this area. In this paper, we consider a Time Series Analysis of the stock price of the big company UnitedHealth Group Incorporated (UNH). UnitedHealth Group operates through its subsidiary United Healthcare, which offers a wide range of health insurance plans for individuals and employers. Using R codes studies the first-order autoregressive process AR(1) with application to the UNH stocks monthly price for 01/01/2010-01/01/2023 was calculated, as well as a time-dependent graphical analysis was performed.

MB4 - SS02: Intelligent Systems and Fuzzy Modeling-2
Monday, August 21, 17:00~18:20, Room 323B
Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-1	Design of Indoor Obstacle Avoidance Control with Monocular Visual Odometry
(17:00 ~ 17:20)	*Rui-Qian Zhang, Chin-Wang Tao (National Ilan University, Taiwan), Chen Chiang, Sheng-En Lin, Chia-Wen Chang (Ming Chuan University, Taiwan)*

Keywords: SLAM, Obstacle avoidance

This paper uses the direct method to achieve visual synchronization positioning and drawing. The experimental equipment used is a rolling shutter structure camera, which combines the application of a simulated robot while maintaining the stability of the image and realizes the application of visualization by simulating the motion decision of the robot through the depth of the image.
The single camera positioning system can be successfully built, and the appropriate movement strategy can be given according to the distance from the obstacle in the environment, which helps to reduce the This result helps to reduce the cost of robotic systems and maintain similar positioning and navigation performance as high-cost LiDAR.

MB4 SS02: Intelligent Systems and Fuzzy Modeling-2

Monday, August 21, 17:00~18:20, Room 323B

Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-2   Implementing Extreme Climate Reservoir Inflow Prediction based on Interval (17:20 ~ 17:40)   **Type-2 Fuzzy Logic**

> *Hao-Han Tsao, Yih-Guang Leu (National Taiwan Normal University, Taiwan)*

Keywords: IT2FS, Genetic Algorithm, Meteorological forecast data, Reservoir Inflow Forecasting

Hydroelectric power, with its energy storage capabilities and ability to quickly start and stop, is a reliable source of energy that plays a crucial role in power dispatch. However, in the event of heavy rain, the power generators in the watershed may not be able to accommodate the excessive influx of water, leading to the need for flood discharge decisions, which could result in significant waste of power resources. If a rise in water levels can be predicted in advance and the water in the reservoir is consumed for power generation, it can avoid the need for flood discharge decisions in order to prevent the occurrence of such a situation. Through the design of an interval type-2 fuzzy logic-based model, this paper has developed a 48-hour hourly reservoir inflow prediction model. The relevant parameters were trained using the Genetic Algorithms, and the model was submitted to the Techi Reservoir in Taiwan to verify its effectiveness.

MB4 - SS02: Intelligent Systems and Fuzzy Modeling-2

Monday, August 21, 17:00~18:20, Room 323B

Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

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MB4-3   Dynamic and Shared Resource Deployment using Graph Attention Technique (17:40 ~ 18:00)   *Sujitha Venkatapathy (Dr. N. G. P. Institute of Engineering and Technology, India), Thiruvenkadam Srinivasan (Vellore Institute of Technology, India), In-Ho Ra, Han-Gue Jo (Kunsan National University, Korea)*

Keywords: 5G network, Virtual Network Embedding, Graph Attention Network, Naïve Bayes, Reinforcement Learning

Network slicing is a promising technique for making 5G networks flexible and dynamic. By using network virtualization (NV), it is possible to have many, completely separate virtual networks sharing the same underlying physical network. In 5G and beyond networks, the placement and connectivity of virtual networks to the underlying physical network is determined by the virtual network embedding (VNE). Using the naïve bayes algorithm, we present a new method in this study for generating initial slices. Graph attention networks (GAT) and reinforcement learning are utilized to determine the placement and connectivity of slices. Three different performance metrics are utilized

to verify the performance of present method. Overall, this approach shows great promise in improving the efficiency and effectiveness of 5G network slicing.

MB4 SS02: Intelligent Systems and Fuzzy Modeling-2

Monday, August 21, 17:00~18:20, Room 323B

Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-4   Enhancing Lung Disease Diagnosis via Semi-Supervised Machine Learning
(18:00 ~ 18:20)   *Xiaoran Xu, Ravi Sankar (University of South Florida, USA), In-Ho Ra (Kunsan National University, Korea)*

Keywords: Lung sounds, MFCC+CNN, semi-supervised

Lung diseases, including lung cancer and COPD, are significant health concerns globally. Traditional diagnostic methods can be costly, time-consuming, and invasive. This study investigates the use of semi-supervised learning methods for lung sound signal detection using a model combination of MFCC+CNN. By introducing semi-supervised learning modules such as Mix-Match, Co-Refinement, and Co-Refurbishing, we aim to enhance the detection performance while reducing dependence on manual annotations. With the add-on semi-supervised modules, the accuracy rate of the MFCC+CNN model is 92.9%, an increase of 3.8% to the baseline model. The research contributes to the field of lung disease sound detection by addressing challenges such as individual differences, feature complexity, and insufficient labeled data.

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MB4 SS02: Intelligent Systems and Fuzzy Modeling-2

Monday, August 21, 17:00~18:20, Room 323B

Chair: Chia-Wen Chang (Ming Chuan University, Taiwan)

MB4-5   Comparative Analysis of Speech Features in the Aspect of Parkinson's Disease
(18:20 ~ 18:40)   **Classification Based on Machine Learning Methods**
Ruchira Pratihar, Ravi Sankar (University of South Florida, USA), In-Ho Ra (Kunsan National University, Korea)

Keywords: Parkinson's disease, Classification, Feature Extraction, Jitters, Shimmer, t-SNE.

The etiology of Parkinson's disease (PD) is the loss of dopaminergic neurons which are responsible for regulating motor function, cognitive executive function, and emotional limbic activity. Some of the common symptoms of Parkinson's disease are bradykinesia, dysarthria, dysphonia etc. As a result, speech signal is employed for the purpose of classification of Parkinson's disease. The application of

machine learning models using time domain, frequency domain and time-frequency domain features extracted from speech signal for the purpose of classifying PD patients are in current practice. Some of the state-of-the-art methods have selected sets of features that are used as the input of the machine learning models. Deep Neural networks are also implemented for the classification task in recent research works. In this paper, we compare the significance of traditionally used feature sets extracted from speech and have seen that a set of features has superior performance and some

traditionally used features such as relative jitters and shimmers do not have much significance in the task of classification for Parkinson's Disease.

Abstract

Tuesday

August 22, 2023

TA1 Dynamical Modeling and Engineering Applications
Tuesday, August 22, 09:00~10:20, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

TA1-1
(09:00 ~ 09:20)

Analysis of Chaotic Behaviors in Fuzzy Happiness Model with an External Force and Resilience considering Gaussian Noise
Jin Hee Yoon (Sejong University, Korea), Youngchul Bae (Chonnam National University, Korea)

Keywords: Fuzzy Chaotic behavior, Happiness model, Fuzzy trapezoidal membership function, Exponential decay, Gaussian noise.

The happiness model is known as the differential equation that can represent how a person feels happy with respect to the time when the positive or negative external force is changed. Because happiness is a person's feeling that includes vagueness and ambiguity of human's emotion, it is reasonable to express such human's emotion using fuzzy trapezoidal numbers due to the ambiguity. Even more the external force also can express some external influence that is also can be human's response. Especially, since a specific external force often decreases over time, an exponential function that decreases initially and converges to zero as time passes rather than a simple sine function was applied to a sine function with a certain periodicity. Therefore, in this paper the fuzzy happiness model using an external force, which is represented by sinusoidal function that has exponential decay with Gaussian noise has been proposed.

TA1 Dynamical Modeling and Engineering Applications
Tuesday, August 22, 09:00~10:20, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

TA1-2
(09:20 ~ 09:40)
Fuzzy Based Power Sharing in Parallel Neutral Point Clamped Inverter for Microgrid Applications
M. Kowsalya (Vellore Institute of Technology, India), Hyung-Jin Kim (Jeonbuk National University, Korea), In-Ho Ra (Kunsan National University, Korea)

Keywords: parallel operated inverters, current sharing, fuzzy based PI, reinforced droop control

This paper investigates the fuzzy based active current sharing in parallel 3-level Neutral Point Clamped (NPC) inverter for islanded AC microgrid application. In distribution generation, parallel power electronics interface based microgrid suffers from the power quality issues due to inaccurate output current sharing. To address the current sharing problem, this paper proposes a fuzzy based reinforced droop loop by infusing the incurred voltage drop accountable for inaccurate current sharing at the inverter output. The control based on droop reference is bounded with regard to output current of the inverter largely. Besides that, the NPC inverter also suffers from DC voltage imbalance due to neutral currents. To handle these issues a control strategy is proposed in the research work where the processed DC offset is incorporated into the reinforced droop loop and the generated reference is utilized with feedback control to accurately share the currents under linear load conditions. The effectiveness of the devised fuzzy based reinforced droop strategy is realized in MATLAB/Simulink environment.

TA1 Dynamical Modeling and Engineering Applications
Tuesday, August 22, 09:00~10:20, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

TA1-3
(09:40 ~ 10:00)
Takagi-Sugeno Fuzzy Modelling of Electric Vehicle Steering System
Hugang Han, Shinji Shigemaru (Prefectural University of Hiroshima, Japan), Miyu Shimizu (Shimane Johoshori Center Inc., Japan)

Index Terms: Electric vehicle (EV) steering system, Takagi-Sugeno (T-S) fuzzy model, uncertainty,

Sector nonlinearity

Electric vehicle (EV) steering control becomes much more important in many senses such as environmental awareness and driving comfort and safety. In view of controller design crucially depending on a proper mathematical model, this paper focuses on fuzzy modelling of EV steering system. Unlike the traditional internal combustion engine powered vehicles that possess only one control input related to the steering wheel, the so-called direct yaw moment control is yet another control input in EVs thanks to the dispersedly located in-wheel motors. With later controller design and control system robustness in mind, uncertainty to deal with modelling error is considered in the model properly along with visually clear steering structure of EVs. Then, a Takagi-Sugeno (T-S) fuzzy model is obtained based on the EV's model, which is capable of varying vehicle velocity in a range. Finally, the precision of the T-S fuzzy model is shown in computer simulations.

TA1 Dynamical Modeling and Engineering Applications
Tuesday, August 22, 09:00~10:20, Room 323A
Chair: Jin Hee Yoon (Sejong University, Korea)

TA1-4   **Mealy-type L-fuzzy Multiset Automata and Its Characterization**
(10:00 ~ 10:20)   *Mallika Dhingra, M. K. Dubey (Manipal University Jaipur, India)*

Keywords: Multiset; Mealy-type fuzzy multiset automaton; input-output multiset behavior.

The concept of multisets has shown to be useful in the area of mathematical logic and theoretical computer science. The objective of this research work is to introduce the concept of Mealy-type Lfuzzy multiset automata and then characterize them with their input-output multisets. We illustrate these ideas with concrete examples.
Next, we present the notions of an inputoutput L-fuzzy multiset behavior, observability, and bisimulation for a Mealy-type Lfuzzy multiset automata.

TB1 Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc
Tuesday, August 22, 09:00~10:20, Room 323B
Chair: Bart Kosko (University of Southern California, USA)

TB1-1   **Searching for Causal Phantom Nodes in Fuzzy Cognitive Maps**
(09:00 ~ 09:20)   *Akash Kumar Panda, Bart Kosko (University of Southern California, USA)*

Index Terms: causal inference, fuzzy cognitive maps, hidden variables, causal learning, AI hallucinations

We call causal variables phantom nodes in a fuzzy cognitive map (FCM) if they affect the FCM but the FCM does not include them in its web of nodes and causal edges. Supervised and unsupervised learning schemes can estimate the causal connections to a phantom node based on how the learned causal edges affect the FCM's equilibrium attractors. We illustrate this technique with gradient descent on the wellstudied dolphin FCM. The process starts with the 5-node FCM and finds its equilibrium limit cycles. Then we remove one of the nodes and treat it as a phantom node and train. Gradient learning trains the augmented FCM with samples from the FCM edges using the known target limit cycles. The simulations used squared error as the performance measure but other measures can apply. The causal learning methodology extends to more than one phantom node but at greater computational cost.

TB1 Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc
Tuesday, August 22, 09:00~10:20, Room 323B
Chair: Bart Kosko (University of Southern California, USA)

TB1-2   **A Fuzzy Transformer Network with Neuro-Fuzzy Loss for Phishing URL**
(09:20 ~ 09:40)   **Detection**
                    Seok-Jun Bu, Sung-Bae Cho (Yonsei University, Korea)

Keywords: Phishing URL detection, Neuro-fuzzy loss, Fuzzy transformer, Deep learning

Phishing attacks exploit deceptive URLs to deceive users and compromise sensitive information, necessitating adaptive detection methods. In this paper, we propose a fuzzy transformer network with neuro-fuzzy loss, combining the strengths of fuzzy logic and transformer-based neural networks for phishing URL detection. Our architecture integrates a belief trainable fuzzy layer within the transformer network, enabling adaptation to evolving phishing tactics while maintaining interpretability. The neuro-fuzzy loss guides the training process based on the fuzzy layer's output confidence, enhancing the model's adaptability and robustness. We conduct rigorous evaluations on real-world datasets, demonstrating the superior accuracy of our proposed approach compared to traditional deep learning models. In periodic experimental settings that mimic real-world phishing detection conditions, our model achieves significant performance improvements. Furthermore, we analyze the reliability of detection rules and evaluate their confidence and support within the fuzzy transformer network. Visualizations of the fuzzy layer parameters using t-SNE provide valuable insights into the successful classification of phishing URLs.

TB1 Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc
Tuesday, August 22, 09:00~10:20, Room 323B
Chair: Bart Kosko (University of Southern California, USA)

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TB1-3   **On Quasi-intents in Complete Fuzzy Lattices**
(09:40 ~ 10:00)   *Manuel Ojeda-Hernandez, Inma P. Cabrera, Pablo Cordero, Emilio MunozVelasco (Universidad de Malaga, Spain)*

Formal Concept Analysis (FCA) is a mathematical framework for analysing data tables that capture the relationship between objects and attributes. FCA deals with two main structures of knowledge, namely the concept lattice and the basis of attribute implications. There are several sets of implications in the literature, for instance minimal bases, direct bases or direct minimal bases. In this work we are interested in the concept of pseudointent in the fuzzy framework in order to define the Duquenne-Guigues basis in the fuzzy setting.

TB1 Fuzzy Theory, Rough Sets, and Formal Concept Analysis etc
Tuesday, August 22, 09:00~10:20, Room 323B
Chair: Bart Kosko (University of Southern California, USA)

TB1-4   **Stratified Multi-adjoint Normal Logic Programs**
(10:00 ~ 10:20)   *M. Eugenia Cornejo, David Lobo, Jesús Medina (University of Cádiz, Spain)*

Keywords: Multi-adjoint logic program, Negation operator, Stable model, Stratified program, fuzzy rule

Multi-adjoint normal logic programming is a non-monotonic logic programming framework in which the propositional symbols take values in a complete lattice and different adjoint pairs can be considered for defining fuzzy rules. The semantics of multi-adjoint normal logic programs is defined in terms of stable models, and a semantical sufficient condition for the existence and the uniqueness of stable models has already been presented.
In this paper, we provide a syntactical sufficient condition for the existence and uniqueness of stable models in multiadjoint normal logic programming basing on the concept of stratification.

TA2 Data Analysis: Clustering, Associations Mining, Classification-1
Tuesday, August 22, 10:40~11:40, Room 323A
Chair: Kwang Baek Kim (Silla University, Korea)

TA2-1   **Robust Neuro-Fuzzy Inference in Dog Disease Pre-Diagnosis System for Casual** (10:40 ~ 11:00) **Owners**
         Kwang Baek Kim, Won Hee Son (Silla University, Korea), Yu Jeong Jeong, Gun Woong Lee (SAIZYE Co., Ltd, Korea), Doo Heon Song (Yong-In Art & Science University, Korea)

Keywords: Pet Disease Pre-diagnosis, Neuro-Fuzzy inference, FCM, Robustness

Korean pet dog owners who care relatively older dogs need reliable first-hand information system that provides pre-diagnosis and appropriate coping strategy information against observed abnormal behavior of their pet dog. In this paper, we propose such a system based on a neuro-fuzzy inference algorithm for the robustness of the information system since casual owners tend to provide partially incorrect or irrelevant symptoms as input. In experiment, we verify that the proposed algorithm is sufficiently noise tolerant and at the same time, it is accurate when relevant features are provided as input.

TA2 Data Analysis: Clustering, Associations Mining, Classification-1
Tuesday, August 22, 10:40~11:40, Room 323A
Chair: Kwang Baek Kim (Silla University, Korea)

TA2-2   **A Study on Synthetic Data Generation for Fall Detection**
(11:00 ~ 11:20)   *Yeonwoo Choi, Bongjun Kim, Junho Jeong (Dongguk University, Korea)*

Keywords: Action Recognition, Computer Vision, Fall Detection, Synthetic Data, Unreal Engine

A fall is an accident in which a person falls in an unpredictable situation, which can lead to serious injuries such as fractures and concussions and requires a quick response. In order to study visionbased human Action recognition deep learning models for complex indoor activities, large-scale activity datasets are required, but there is a limitation that it is difficult to utilize them for deep learning model research because there are differences in camera viewpoints, shooting angles, lighting, etc. between the surveillance environment and public datasets to be applied in practice, and the amount of required data is insufficient. Recently, research has been conducted to improve the performance of public datasets by using pre-captured motion data in a virtual environment to generate synthetic data and train models. However, these existing studies require manual manipulation of captured motion data. In this study, we apply physics-based animation to fall animation data using a game engine to generate synthetic data for fall detection model training.

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TA2-3   **Social Networks Analysis and Fuzzy Measures: a General Approach to Improve** (11:20 ~
11:40)   **Community Detection in Directed Graphs**
       Inmaculada Gutiérrez, María Barroso, Daniel Gómez, Javier Castro
       (Complutense University of Madrid, Spain)

Keywords: Flow capacity measure, Fuzzy measures, Directed networks, Community detection, Directed modularity

Community detection aims to divide a network into groups with high internal connectivity and low external connectivity. This task is more complex in directed networks, where group density is crucial. To improve accuracy, researchers have used fuzzy measures to incorporate additional information beyond the network's topological structure. Previous works have focused on modifying existing algorithms such as the Louvain method to incorporate additional properties from directed networks in the grouping process. In this work, we propose a novel pre-processing method to address this challenge. By combining structural information with flow capacity measures, we obtain a more realistic input for algorithms applicable to different methods. Through a supervised approach, we

establish a pre-processing method to enhance solutions. We show the effectiveness of this approach on various community detection algorithms.

TB2 SS03: Interval Uncertainty
Tuesday, August 22, 10:40~11:40, Room 323B
Chair: Vladik Kreinovich (University of Texas at El Paso, USA)

TB2-1   **Natural Color Interpretation of Interval-Valued Fuzzy Degrees**
(10:40 ~ 11:00)   *Victor L. Timchenko (Admiral Makarov National Univ. of Shipbuilding, Ukraine),*
       Yury P. Kondratenko (Petro Mohyla Black Sea National Univ., Ukraine), Vladik
       Kreinovich, Olga Kosheleva (Univ. of Texas at El Paso, USA)

Keywords: Interval-valued fuzzy, Optical computing, Z-numbers

Intuitively, interval-values fuzzy degrees are more adequate for representing expert uncertainty than the traditional [0,1]-based ones. Indeed, the very need for fuzzy degrees comes from the fact that experts often cannot describe their opinion not in terms of precise numbers, but by using imprecise ("fuzzy") words from natural language like "small". In such situations, it is strange to expect the same expert to be able to provide an exact number describing his/her degree of certainty; it is more natural to ask this expert to mark the whole interval (or even, more generally, a fuzzy set of possible degrees). In spite of this intuitive adequacy, and in spite of several successful applications of intervalvalued degrees, most applications of fuzzy techniques are still based on the traditional [0,1]-based degrees. According to researcher who studied this puzzling phenomenon, the problem is that while people are

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accustomed to marking their opinion on a numerical scale, most people do not have any experience of using interval. To ease people's use of interval-valued degrees, we propose to take into account that the set of all interval-valued degrees is, in some reasonable sense, equivalent to the set of colors – thus, we can represent degrees as appropriate colors. This idea can be naturally extended to Z-numbers – and it also provides an additional argument why interval-valued degrees are more adequate, at least more adequate in the analysis of complex phenomena.

TB2 SS03: Interval Uncertainty
Tuesday, August 22, 10:40~11:40, Room 323B
Chair: Vladik Kreinovich (University of Texas at El Paso, USA)

TB2-2   **Is Fully Explainable AI Even Possible: Fuzzy-Based Analysis**
(11:00 ~ 11:20)   *Miroslav Svitek (Czech Techn. Univ. in Prague, Czech Republic), Olga Kosheleva,*
       Vladik Kreinovich (Univ. of Texas at El Paso, USA)

Keywords: Explainable AI, Fuzzy logic, Explainability in physics, Interval computations

One of the main limitations of many current AI-based decision-making systems is that they do not provide any understandable explanations of how they came up with the produced decision. Taking into account that these systems are not perfect, that their decisions are sometimes far from good, the absence of an explanation makes it difficult to separate good decisions from suspicious ones. Because of this, many researchers are working on making AI explainable. In some applications areas – e.g., in chess – practitioners get an impression that there is a limit to understandability, that some decisions

remain inhuman – not explainable. In this paper, we use fuzzy techniques to analyze this situation. We show that for relatively simpler systems, explainable model are indeed optimal approximate descriptions, while for more complex systems, there is a limit on the adequacy of explainable models.

TB2 SS03: Interval Uncertainty
Tuesday, August 22, 10:40~11:40, Room 323B
Chair: Vladik Kreinovich (University of Texas at El Paso, USA)

TB2-3	**Logical Inference Inevitably Appears: Fuzzy-Based Explanation**
(11:20 ~ 11:40)	*Julio Urenda, Olga Kosheleva, Vladik Kreinovich (Univ. of Texas at El Paso, USA), Orsolya Csiszar (Aalen Univ. of Applied Sciences, Germany)*

Keywords: Logical reasoning, Fuzzy logic, Historical emergence of logical reasoning, Schur's theorem

Many thousands years ago, our primitive ancestors did not have the ability to reason logically and to perform logical inference. This ability appeared later. A natural question is: was this appearance inevitable – or was this a lucky incident that could have been missed?
In this paper, we use fuzzy techniques to provide a possible answer to this question. Our answer is: yes, the appearance of logical inference in inevitable.

Data Analysis: Clustering, Associations Mining, Classification-2
Tuesday, August 22, 13:20~15:00, Room 323A
Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-1	**Towards Interpreting Topic Models with ChatGPT**
(13:20 ~ 13:40)	*Emil Rijcken, Kalliopi Zervanou, Uzay Kaymak (Eindhoven University of Technology, The Netherlands), Floortje Scheepers (University Medical Centre Utrecht, The Netherlands), Marco Spruit (Leiden University, The Netherlands), Pablo Mosteiro (Utrecht University, The Netherlands)*

Index Terms: Topic Modeling, LLM, ChatGPT, Electronic Health Records, Fuzzy Topic Models, Prompt Engineering

Topic modeling has become a popular approach to identify semantic structures in text corpora. Despite its wide applications, interpreting the outputs of topic models remains challenging. This paper presents an initial study regarding a new approach to better understand this output, leveraging the large language model ChatGPT. Our approach is built on a threestage process where we first use topic modeling to identify the main topics in the corpus. Then, we ask a domain expert to assign themes to these topics and prompt ChatGPT to generate humanreadable summaries of the topics. Lastly, we compare the humanand machine-produced interpretations. The domain expert found half of ChatGPT's descriptions useful. This explorative work demonstrates ChatGPT's capability to describe topics accurately and provide useful insights if prompted accurately.

TA3 Data Analysis: Clustering, Associations Mining, Classification-2
Tuesday, August 22, 13:20~15:00, Room 323A
Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-2 **Revised Optimization Algorithm for Maximum-Margin Nearest Prototype** (13:40 ~ 14:00)
Classifier
Yoshifumi Kusunoki, Tomoharu Nakashima (Osaka Metropolitan Univ., Japan)

Keywords: Nearest prototype classifier, Margin maximization, Supervised learning, Convex-concave procedure

In this paper, we study nearest prototype classifiers, a type of classification algorithms that utilizes labeled prototypes. We revise our maximum-margin model for nearest prototype classifiers, which is formulated by a DC (difference of convex functions) optimization problem, and solved using CCP (convex-concave procedure), which is a kmeans-like algorithm. We modify the convex composite function used to formulate a convex approximation problem solved in CCP. Moreover, we propose a new initialization method for the algorithm. By numerical experiments, we demonstrate that the proposed method works correctly.

Data Analysis: Clustering, Associations Mining, Classification-2
Tuesday, August 22, 13:20~15:00, Room 323A

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Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-3 **Evaluation of Bagging-type Ensemble Method Generating Virtual Data** (14:00 ~ 14:20)
Honoka Irie, Isao Hayashi (Kansai University, Japan)

Index Terms: Fuzzy Inference, Virtual Data, Ensemble Method, Bagging, Clustering

For pattern classification problems, an ensemblelearning method identifies multiple weak classifiers using learning data and combines them to improve the discrimination rate of testing data. We have previously proposed possibilistic data interpolation bagging (pdi-Bagging), which improved the discrimination rate of testing data by adding virtually generated data to the learning data. However, the accuracy of the correct virtual data type is unstable because the virtual data are generated over a wide area of the data space. In addition, the discriminant accuracy is low because the evaluation index for changing the generation class of the virtual data is defined in each dimension. In this study, we propose a new method for specifying the generation area of virtual data and changing the generation class of the virtual data. Consequently, the discriminant accuracy improved because five new bagging methods that generate virtual data around the correct discrimination data and error discrimination data are formulated, and the class of virtual data is determined using the proposed new evaluation index in multidimensional space. We formulate the new pdi-Bagging algorithm and discuss the usefulness of the proposed method using numerical examples.

TA3 Data Analysis: Clustering, Associations Mining, Classification-2
Tuesday, August 22, 13:20~15:00, Room 323A
Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-4 **Explainable Malware Detection Model through Dynamic Residual Kernel**
(14:20 ~ 14:40) **Generation**
Mainak Basak, Myung-Mook Han (Gachon University, Korea)

Keywords: Malware analysis, Explainable AI, Residual network, Attention

The categorization of malware variants has received significant attention, but challenges persist such as low accuracy in categorizing similar malware families, high false negatives, and resource-intensive processing. Malware authors have evaded signature-based detection, and static analysis methods rely heavily on parsing tools. Dynamic analysis requires sandboxed environments, but virtual environments can hide malicious behavior. In our study, we propose representing malware as images and training a classifier using neural network approaches. This approach enables accurate classification of new malware files, independent of specific programs and with reduced processing time. By integrating Dynamic Residual Kernel (DRK)[1] and deep residual blocks, our methods achieved a remarkable 98.81% improvement over the equal probability benchmark, enhancing malware classification accuracy while mitigating resource consumption.

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Data Analysis: Clustering, Associations Mining, Classification-2
Tuesday, August 22, 13:20~15:00, Room 323A
Chair: Uzay Kaymak (Eindhoven University of Technology, The Netherlands)

TA3-5 **A Study on the Creation of Improved 3D Models and Large-Scale Datasets** (14:40 ~ 15:00)
Using NeRF
Min-Hong Park, Jae-Hoon Cho, Yong-Tae Kim (Hankyong National Univ., Korea)

Keywords: NeRF, 3D object, large-scale datasets, segmentation, deep learning, photogrammetry

In this paper, we propose a 3D model generation technique using NeRF(Neural Radiance Fields). The proposed technique creates an improved 3D object compared to existing creating techniques of 3D object models. The created 3D object model enables the rapid creation of large-scale datasets for segmentation or pose recognition using deep learning model. To evaluate the performance of the proposed method, it was compared with existing 3D object model creation methods, and we show that the proposed method creates 3D objects that are effective in creating training data for various deep learning models.

Woo Jung (Dongguk University

TB3-1 **Deep Learning-based Human Activity Recognition using Dilated CNN and LSTM** (13:20 ~
13:40) **on UCF-50 Video Dataset**
Bakht Alam Khan, Kwon Si Yeon, Jin-Woo Jung (Dongguk University, Korea)

Keywords: human activity recognition, Dilated CNN, LSTM, UCF 50 dataset, spatial-temporal information

Human Activity Recognition (HAR) is essential in various domains, including surveillance, healthcare, and robotics. In this study, we introduce a novel approach for HAR using a combination of Dilated Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks. The proposed model achieves a remarkable accuracy of 94.9%, outperforming the traditional CNN-LSTM model (93,7%) on the UCF 50 dataset. Dilated CNNs are employed to capture a wider range of spatialtemporal information by increasing the receptive field. This allows the model to effectively recognize complex human activities. The advantages of dilated CNNs include the ability to preserve finegrained details while maintaining computational efficiency. By incorporating LSTM layers, the model successfully captures temporal dependencies, enabling it to understand the sequential nature of human actions. Furthermore, We evaluated the generalization of our model by testing it on a random YouTube video, showcasing its adaptability to real-world scenarios. The exceptional performance of our approach highlights its potential impact in surveillance systems, humancomputer interaction, and healthcare activity monitoring.

Recently, the human interface is actively developing for a society undergoing digital transformation (DX). This paper discusses the development of a user-friendly interface for a smart home system. As a general system control method, many systems such as remote controllers and smart speakers have been proposed, but it has not been established which system is effective from the user's point of view. Therefore, we focus the investigation on how the proposed smart home control system is effective for users. This study developed two control methods: interface development using the user's gesture and interface using a smart device. After using the interface system, an analysis is conducted based on questionnaire results, and we discuss the effectiveness of the proposed system.

TB3-2 **Development of a User-friendly Interface for a Smart Home System based on** (13:40 ~
14:00) **IoT Technology**
Chifuyu Matsumoto, Yuka Sone, Jinseok Woo, Yasuhiro Ohyama (Tokyo University of Technology, Japan)

Keywords: Human interface, IoT Technology, Smart device, Smart home system, intuitive control

TB3 - SS05: High Performance Knowledge System and Its Application to Intelligent Systems for the Elderly
Tuesday, August 22, 13:20~15:00, Room 323B
Chair: Jin-   , Korea)

Woo Jung (Dongguk University

TB3-3   **Developing a Transformer based model for Extracting Relations Between Rare**
(14:00 ~ 14:20)   **Diseases and Disabilities from Documents**
                       Atif Latif, Jihie Kim (Dongguk University, Korea)

Keywords: Relation Extraction, BERT, Rare Diseases, Disabilities

Several rare diseases e.g., Infantile, Refsum, Costello can cause acute disabilities in patients. Therefore, it is essential to diagnose the diseases in the initial stages and prevent the patient's dire conditions in the future. It is estimated that there are about 400 million people worldwide affected by different rare diseases, even though they have low prevalence. General practitioners face a significant barrier in making an early and correct diagnosis of the diseases due to limited knowledge about them. Additionally, a wide variety of ambiguous symptoms are exhibited by rare diseases, which makes diagnosis more challenging. Applying emerging deep learning techniques such as Natural Language Processing (NLP) for Relation Extraction (RE) provides a promising opportunity in the diagnosis. Several techniques, such as CNN and LSTM can be applied for the relation extraction of different entities. In this work we collected several symptoms of rare diseases from several medical journals and applied Large Language Model (LLMs) for relation extraction to establish a link between rare diseases and disabilities.

Furthermore, we applied Bidirectional Encoder Representations from Transformers (BERT) for Relation Extraction on Rare Diseases and Disabilities RDD corpus. Applying pre-trained model (BERT) on the RDD corpus resulted in significant improvement with F-measure of around 81% for relation extraction. The results show significant improvement over the previously used CNN based model.

TB3 - SS05: High Performance Knowledge System and Its Application to Intelligent Systems for the Elderly
Tuesday, August 22, 13:20~15:00, Room 323B Chair:
Jin-Woo Jung (Dongguk University, Korea)

TB3-4   **CT-Based Airway Segmentation Using a Hybrid Level-set and Growing Seed** (14:20 ~
14:40)   **Technique**
                Nnubia Pascal Nnamdi, MinSuh Seo, Jinkyung Park, Yunsik Son (Dongguk University, Korea)

Keywords: airway segmentation, ct scans, growing seed technique, level-set methods

TA4 - Deep learning, Machine learning, and AI-1
Tuesday, August 22, 15:20~17:00, Room 323A
                                                                    , Korea)

Pulmonary airway segmentation is crucial for diagnosing and monitoring respiratory diseases, providing valuable information on airway wall thickness and luminal area. Techniques like growing seed and level-set methods have been proposed, but they face challenges due to variability in airway morphology, CT image quality, and computational complexity. Therefore, to address these challenges this paper proposes a technique that combines these techniques, capturing airway morphology accurately and reducing computational complexity. This approach refines the airway segmentation obtained using the growing seed technique by incorporating additional image features and enforcing smoothness constraints on the segmented boundary. However, further research is needed to address the challenges of airway segmentation and develop more robust and accurate techniques.

Woo Jung (Dongguk University

TB3-5   **3D Dataset Generation for Airway Segmentation in Chest CT Imaging Based on** (14:40 ~
15:00)   **Color Analysis and Double Threshold Setting Algorithm**
MinSuh Seo, Nnubia Pascal Nnamdi, SeungHyun Woo, Hyeon-Jin Jeon, Yunsik Son (Dongguk University, Korea)

Keywords: Airway Segmentation, Auto-labeling, 3D Object, Color Extraction, Region Growing

Advancements in computer vision technology have led to the increasing use of 3D objectified data in medical diagnosis. In this context, the process of 3D objectifying the shape of the chest in a patient's CT image is of great importance. However, current chest-type 3D modeling methods require significant time and human resources for manual designation of each area of the lungs. To address this issue, this paper proposes an automated system for color classification and regional area designation, based on an analysis of color differences among institutions in CT images. The system utilizes a double threshold setting algorithm to improve performance and generate a CT dataset that can significantly reduce the cost and time associated with airway segmentation in CT images.

Chair: Keon Myung lee (Chungbuk National University

TA4-1   **An Image Transformation-based Time Series Prediction Method**
(15:20 ~ 15:40)   *Sun Woo Jeong, Keon Myung Lee (Chungbuk National University, Korea)*

Keywords: Time series forecasting, Deep learning, 3D convolution. Univariate time series

Time-series prediction is one of important problems in industrial and business domains because many manufacturing and service systems keep generating some data during their operations. This paper proposes a deep learning model that takes an image which is a converted representation of time series data and make a horizontal prediction. The proposed deep learning model is organized into a stack of 3D LSTM modules and 3D convolution layer. The experiments on some benchmark datasets have shown the proposed method could show comparable performances to existing deep learning-based methods.

TA4 Deep learning, Machine learning, and AI-1
Tuesday, August 22, 15:20~17:00, Room 323A Chair: Keon
Myung lee (Chungbuk National University, Korea)

Tuesday, August 22, 15:20~17:00, Room 323A

, Korea)

accuracy of 0.833. Such a proposed solution will be useful for medical doctors as it will help them to get accurate predictions thus guiding for a better clinical diagnosis and treatment process.

TA4-2   **Basic Application and Methodologies used for Sentiment Analysis: A Survey**
(15:40 ~ 16:00)   *Dayal Aakanksha, Kounen Fathima, Ali Athar, Hee-Cheol Kim (Inje University, Korea)*

Keywords: Naïve Bayes algorithm, Machine Learning, Artificial Intelligence, Sentiment Analysis, Natural Language Processing (NLP).

Sentiment analysis is an area of text mining, that is an active area of research. Sentiment analysis involves the identification of sentiments or opinions in text and has multiple applications, such as customer feedback analysis, product analysis, examining healthcare data, and monitoring brands. The paper focuses on the sentiment analysis techniques applied to text data. The paper also elaborates on the applications of sentiment analysis in healthcare, social media monitoring and Foreseeing Stock and sentiment mining of the stock market including fuzzy logic, along with the associated challenges. The healthcare industry can benefit from automated NLP methods as they help structure synoptic reports, while detecting sarcasm in social media is challenging for NLP algorithms due to the complexity of expressions.

Chair: Keon Myung lee (Chungbuk National University

TA4-3   Lymph Node Metastasis Prediction in Gastric Cancer Using Clinical Feature (16:00 ~
16:20)   **Variables and Machine Learning**
          Tagne Poupi Theodore, Abdullah, Sikandar Ali, Hee-Cheol Kim (Inje University, Korea)

Keywords: Gastric cancer, Lymph node metastasis, Machine learning

In this study, we use machine learning techniques to predict lymph node metastasis in gastric cancer. To achieve our goal, we used a dataset of 1291 patient records from CHA Bundang Medical Center and Ewha Womans University Mokdong Hospital in South Korea. Necessary pre-processing techniques were used on the dataset to make them ready for training. After training, a random set of 100 data was used for external validation and the XGBoost classifier achieved the best performance with an AUC score of 0.89. The validity of the study was achieved using a 5-fold validation with an average

TA4 Deep learning, Machine learning, and AI-1
Tuesday, August 22, 15:20~17:00, Room 323A Chair: Keon
Myung lee (Chungbuk National University, Korea)

TA4-4 **Dexterous Hand-Object Grasp Control With Prosthetic Hand**
(16:20 ~ 16:40) *Sanghun Kim, Jiho Park, Jihie Kim, Hyeryung Jang (Dongguk University, Korea),*
Zhongqun Zhang, Hyung Jin Chang (University of Birmingham, UK)

Keywords: Prosthesis, Robotics, Hand-object interaction, Data augmentation

The use of human hand models to investigate the interaction between the hand and objects is a wellestablished research field. However, the manipulation of interaction between prosthetic hands and objects is an underexplored area. In this study, we aimed to replace the human hand model with a prosthetic hand and develop a physically realistic grasp and motion synthesis model. Our objective was to evaluate whether this model could generate motion patterns that were comparable to the baseline model using the human hand model. Our investigation exposed the challenges we encountered during this approach and the tactics we developed to tackle these issues, thus providing valuable insights for future research.

Chair: Keon Myung lee (Chungbuk National University

TA4-5 **Non-Contact Material Recognition from a Test-bench Using Reflected Sound**
(16:40 ~ 17:00) **Waves and Machine Learning**
Min-Hyun Kim, Joongeun Jung (MoveAWheeL, Inc., Korea)

Keywords: Material recognition, Sound sensor, Machine learning

This study presents a novel approach that integrates non-contact sound sensors and machine learning techniques for the detection and classification of transparent materials, achieving a remarkable accuracy rate of 97%. The developed system analyzes the reflective characteristics of diverse materials, including transparent black ice, enabling real-time detection and prediction of hazardous road conditions, thereby enhancing overall road safety.

TB4 SS06: Maritime Intelligent Systems
Tuesday, August 22, 15:20~16:40, Room 323B
Chair: Joo-Sung Kim (Mokpo National Maritime University, Korea)

TB4-1 **Development of Ship's Route Planning Method and Risk Assessment in Vessel** (15:20 ~
15:40) **Traffic Services Areas**
> *Da-Un Jang, Joo-Sung Kim, Jung-Sik Jeong, Ho Namgung (Mokpo National*
> *Maritime University, Korea)*

Keywords: Route planning, VTS area, Risk Assessment

Coastal waters are areas where maritime traffic is congested, and a high level of risk exists due to obstacles, shallow waters, and entry or outgoing vessels. To reduce the marine traffic risk of ships in coastal waters, each government department designates routes within coastal waters for risk and control the traffic flow of ships through VTS according to the environment of the area. In this study, safe and efficient route was searched in the area managed through VTS through an improved sampling algorithm-based route planning method reflecting the maneuvering condition of the ship. In addition, the safety of the searched route was verified through a maritime traffic risk assessment model. First, ENC images were imported to generate the VTS sea area for searching route. In addition, the obstacle area was set in consideration of the maneuverability of the ship and the navigation space within the VTS area was configured through image processing method. Next, target area for simulation was selected as the approaching Mokpo Port in Korea. As a result of the simulation, it was confirmed that the total navigation distance was shortened by 1.5 times compared to the original RRT* algorithm. In addition, the risk assessment for the searched route was assessed through the ES Model which calculates the stress value of the ship operator's maneuvering environment, and it was confirmed that the safety acceptance standard for all sections.

TA4 - Deep learning, Machine learning, and AI-1

Tuesday, August 22, 15:20~17:00, Room 323A

, Korea)

TB4 SS06: Maritime Intelligent Systems
Tuesday, August 22, 15:20~16:40, Room 323B
Chair: Joo-Sung Kim (Mokpo National Maritime University, Korea)

TB4-2 **Prediction of Anchor Dragging Risk for Ship at Anchor Using Machine Learning** (15:40 ~
16:00) **on Imbalanced Data**
> *Shem Otoi Onyango, Kwang Il-Kim, Sang-Lok Yoo (Jeju National University,*
> *Korea)*

Keywords: Anchorage, Dragging, Machine learning, Imbalanced data

Anchorages are effective in reducing maritime traffic congestion at the port by serving as a temporary holding area for the provision of vital services to vessels, such as land services (fueling, legal concerns, repairs), cargo loading and unloading, and shelter from adverse weather. Anchor dragging is a serious risk to maritime traffic because it causes collisions with transit traffic, collisions with close vessels at anchor, and the destruction of underwater infrastructure such as pipelines, and cables from the dragged anchor. This study analyzes 1678 examples from 2017 to 2021 to construct a machine-learning model to estimate the risk of anchor dragging for ships at anchorage. The cases were categorized on a binary scale with zero indicating no dragging and one indicating dragging. The data had a binary class ratio of 1:12, indicating that this is a classification problem on imbalanced data. To select the optimum machine learning model, a combination of cost-sensitive machine learning algorithms, data sampling approaches, and adjusted F-beta scores was used. balanced bagging classifier combined with the condensed nearest neighbor had the best F2 score of 0.7131 and a recall score of 1.0.

TB4 SS06: Maritime Intelligent Systems
Tuesday, August 22, 15:20~16:40, Room 323B
Chair: Joo-Sung Kim (Mokpo National Maritime University, Korea)

TB4-3	The Method of Semantic Segmentation Improvement using RescueNet based
(16:00 ~ 16:20)	**PSPNet**
	Habibullaev Sobirjon, Young Sil Lee (Dongseo University, Korea)

Keywords: Semantic Segmentation, Postdisaster damage assessment, PSPNet, RescueNet

Due to climate change increasing rate of natural disasters worldwide can be observed. These catastrophes are causing severe damage to humanity and nature. As a result of the disasters, economic losses are steadily increasing, and the importance of fast and accurate auxiliary tools for rescue teams is growing in saving people's lives and eliminating financial losses. In this regard, by using deep learning algorithms, it is possible to assess the consequences of any disaster that can accurately understand the affected areas. Until now, several successful works have been done by several researchers. The following paper focuses on the experiment to enhance PSPNet model results on RescueNet datasets, which were collected by UAV, by modernizing configurations and datasets.

TB4 SS06: Maritime Intelligent Systems
Tuesday, August 22, 15:20~16:40, Room 323B

Chair: Joo-Sung Kim (Mokpo National Maritime University, Korea)

TB4-4	**Estimation of Floating Debris Volume in an Estuary using U-Net**
(16:20 ~ 16:40)	*Dongwoo Kang, Sung Won Cho, Seung Hyun Lee (Korea Research Institute of*
	Ships and Ocean Engineering, Korea), Jung Sik Jeong (Mokpo National Maritime
	University, Korea)

This study focused on the global issue of marine pollution, with a specific emphasis on floating debris. Using CCTV, we gathered footage from the Geum River Estuary in South Korea and analyzed it using advanced deep learning techniques. We accumulated a total of 446 hours of video data, from which we selected images suitable for our research. With these images, we developed a dataset to estimate the area of floating debris through a deep learningbased image segmentation model, U-net. For model training, we proposed several methods such as area extraction modifications, image size increase, and adjustments to Focal Loss. The model that employed Focal Loss ($\gamma=2$) in combination with U-net showed the best performance, with a Dice coefficient of 0.595. By doing so, our study provides a tool that enables real-time monitoring and prompt intervention in the occurrence of marine debris accumulation. The results of our research are expected to make a significant contribution to marine environmental protection efforts.

Abstract

Wednesday
August 23, 2023

WA1 Deep learning, Machine learning, and AI-2
Wednesday, August 23, 09:00~10:20, Room 323A
Chair: Young-Jae Ryoo (Mokpo National University, Korea)

WA1-1   PERFORMANCE OF DEEPLABV3 WITH DIFFERENT BACKBONES ON SWEET (09:00 ~ 09:20)
PEPPER DATASET

Truong Thi Huong Giang, Young-Jae Ryoo (Mokpo National University, Korea)

Keywords: Semantic segmentation neural network, DeepLabV3, Sweet Pepper

The DeepLabV3 is a highly effective semantic segmentation neural network that has gained significant popularity. In our research, we have utilized this neural network to detect various parts of sweet pepper plants, such as leaves, stems, and petioles, intending to achieve further automation in green farms. The implementation of DeepLabV3 with different backbones can produce varying results. Therefore, we conducted a series of experiments to evaluate the performance of different DeepLabV3 models using the sweet pepper dataset. Our objective was to select the best model to integrate into our automated system.

WA1 Deep learning, Machine learning, and AI-2
Wednesday, August 23, 09:00~10:20, Room 323A
Chair: Young-Jae Ryoo (Mokpo National University, Korea)

WA1-2 **Optimizing Fuzzy Fingerprints from Large Pre-Trained Models using** (09:20 ~ 09:40)
Genetic Algorithms
Rui Ribeiro, Luisa Coheur, Joao P. Carvalho (INESC-ID, Portugal), Rui Jorge Almeida (Maastricht University, The Netherlands)

Keywords: Text Classification; Fuzzy Fingerprints; Large Pre-Trained Models; Optimization

Large pre-trained models such as BERT and RoBERTa are currently used as the state-ofthe-art foundation for Natural Language Processing classification tasks. Fuzzy Fingerprints can be used as a classification layer in such models to improve the interpretability of the classification results, while reducing model complexity and without a significant loss in performance. In this work, we exploit a recent framework that combines Fuzzy Fingerprints with large pre-trained models. By employing a Genetic Algorithm, we further optimize these fingerprints to obtain a hybrid classification model that has the potential to achieve similar performance and become more interpretable while less complex than traditional large pre-trained classifiers. Our experiments show that with a smaller fingerprint size and thus more easily interpretable, the optimization improves the base work with a larger fingerprint size and achieves competing results with state-of-theart approaches.

WA1 Deep learning, Machine learning, and AI-2
Wednesday, August 23, 09:00~10:20, Room 323A
Chair: Young-Jae Ryoo (Mokpo National University, Korea)

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WA1-3 **Cervical Spine Fracture Segmentation Using U-Net**
(09:40 ~ 10:00) *Yaseen Muhammad, Abdullah, Ali Maisam, Ali Sikandar, Hee Cheol Kim (Inje University, Korea), Kwang Baek Kim (Silla University, Korea)*

Keywords: Cervical spine, Computed Tomography (CT), Segmentation, U-Net.

Patients who experience fractures in their spine often encounter difficulties in performing physical movements, preventing them from engaging in their regular routines and employment. Spinal fractures may occur due to accidents or the natural aging process. As per [1], approximately 1.5 million instances of spinal fractures arise every year in the United States. These occurrences tend to impact older individuals and can lead to spinal cord damage, with roughly 18,000 cases reported annually. Accurately diagnosing the area of fracture within a Computed Tomography (CT) scan image can present as a challenging endeavor. To address this issue, the current study employs the U-Net model as a means to successfully segment and identify the vertebrae region. The U-Net model employed in this study has demonstrated a high level of accuracy in identifying and segmenting vertebrae from CT scan images of the spine. The model achieved an accuracy of 86% and Intersection over Union (IOU)

of 0.85 indicating that there is a high level of agreement between the predicted and ground truth segmentation masks. Overall, the high accuracy and IOU values obtained by the U-Net model in this study suggests that it can be a useful tool for assisting medical professionals in accurately diagnosing spinal fractures from CT scan images.

WA1 Deep learning, Machine learning, and AI-2
Wednesday, August 23, 09:00~10:20, Room 323A
Chair: Young-Jae Ryoo (Mokpo National University, Korea)

WA1-4 **Prediction of Chronic Kidney Disease Using Machine Learning**
(10:00 ~ 10:20) *Md Nayeem Hosen, Md Ariful Islam Mozumder, Rashedul Islam Sumon, Hee-Cheol Kim (Inje University, Korea)*

Keywords: Chronic kidney disease, artificial intelligence, machine learning techniques.

A consecutive rise in a particular number of patients with Chronic Kidney Disease Final Stage. In that case where kidney replacement and medical treatment are demanded, which means the kidney should be transplanted or dialysis. So that requires early-stage prediction of chronic kidney disease (CKD), if the patients know about the risk factors, they will be aware of the risks of CKD and get early medical treatment. People with diabetes, hypertension, and the aging population are more likely to develop chronic kidney disease. To overcome these challenges, machine learning techniques are used to diagnose diseases on time. We have employed different types of machine learning algorithms in this paper: Support vector machine classifier (SVM), Random Forest (RF), and Artificial Neural Network (ANN). Training these algorithms was done using data from the UCI repository. CKD is predicted more accurately after preprocessing the data, which improves the accuracy of the prediction algorithms.

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SS04: Forward Looking Decision making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B
Chair: Pasi Luukka (LUT University, Finland)

WB1-1 **Fuzzy Entropy and Similarity Based Feature Selection with Relevancy,**
(09:00 ~ 09:20) **Redundancy and Complementarity Information**
Pasi Luukka (LUT University, Finland)

Keywords: Feature selection, fuzzy entropy, similarity, relevance, redundancy and complementarity information

Many feature selection methods solely concentrated on feature relevancy. In this paper we will focus on information theoretic feature selection measures, which quantify the importance of each feature

by estimating information to capture relevancy, redundancy and complementarity information. Here we concentrate on choosing a subset of features that has the highest relevancy with the output space, the minimum redundancy between them, and the highest complementarity. This helps us to reduce the input space, and at the same time keep as much useful information as possible. Earlier versions of fuzzy entropy and similarity based feature selection have only concentrated on relevancy and we show that adding also redundancy and complementarity information we are able to outperform the previous version. Method is benchmarked with five data sets.

WB1 SS04: Forward Looking Decision-making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B
Chair: Pasi Luukka (LUT University, Finland)

WB1-2 **Enhancing Fuzzy k-nearest Neighbor with Entropy-weighted Minkowski** (09:20 ~ 09:40)
          Distance and Local Means
                    Mahinda Mailagaha Kumbure, Pasi Luukka (LUT University, Finland)

Keywords: Classification, Fuzzy entropy, Minkowski distance, Fuzzy k-nearest neighbor, Local means, Machine learning

This paper proposes an improved fuzzy k-nearest neighbor (FKNN) method called the entropyweighted Minkowski distancebased local mean fuzzy k-nearest neighbor (EWM-LMFKNN), which improves the classification accuracy by utilizing fuzzy entropy, Minkowski distance, and class representative local mean vectors. Using a fuzzy entropy-based feature weighting process and Minkowski distance improves the calculation of distances between instances, resulting in a more accurate set of nearest neighbors. Moreover, the EWM-LMFKNN classifier considers the local structure of class subsets by using local mean vectors instead of individual neighbors, which improves its classification performance. The proposed method was evaluated on various datasets. The results show that it outperformed the traditional KNN, FKNN, and several other state-of-the-art methods and can be an effective classifier.

SS04: Forward Looking Decision making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B
Chair: Pasi Luukka (LUT University, Finland)

WB1-3 **On the Connection between the Generalized Dissemblance Index and** (09:40 ~ 10:00)
          Centers of Gravity of Triangular-type Fuzzy Numbers
                    Jan Stoklasa, Pasi Luukka, Jana Stoklasová (LUT University, Finland)

Keywords: Dissemblance index, Fuzzy number, Distance, COG, Possibilistic mean

This paper investigates the formulation of the dissemblance index as a basis for the calculation of distances of fuzzy numbers and explores its potential linkages with standard and possibilistic moments of fuzzy numbers. Applying the LSC transformation introduced recently by Luukka, Stoklasa and Collan we transform the general formulation of the dissemblance index into its "probabilistic" analogy and show that the result can be interpreted as a difference of COGs of the fuzzy numbers (potentially with hedges applied to them). We also show that the difference of possibilistic means is a special case of the general dissemblance index, when w = 1. We discuss the implications of this relationship on the practical use of dissemblance index.

WB1 SS04: Forward Looking Decision-making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B
Chair: Pasi Luukka (LUT University, Finland)

WB1-4	**Extracting Business-relevance from Highly Imprecise Fuzzy Estimates**
(10:00 ~ 10:20)	*Mikael Collan, Pasi Luukka (LUT University, Finland), Jani Kinnunen (Åbo Akademi University, Finland)*

Keywords: Strategic decision-making, Structural uncertainty, Multi-expert estimation, Trend information

Estimation connected to far forwardlooking strategic business decision-making situations takes place in the presence of high uncertainty that can even be structural. Information is typically in the form of expert estimates that include very high imprecision; the estimates can be gathered in the form of scenarios from which fuzzy number estimates can be generated. This paper explores ways to extract businessrelevant information from the generated fuzzy number estimates in longitudinal and multiexpert estimation situations. A numerical case in the context of strategic patent valuation is presented.

SS04: Forward Looking Decision making under Uncertainty
Wednesday, August 23, 09:00~10:20, Room 323B

Chair: Pasi Luukka (LUT University, Finland)

WB1-5	**Promoting Stability using Ensemble Feature Selection with Evolutionary and Swarm Intelligence Algorithms**
(10:20 ~ 10:40)	*Christoph Lohrmann, Alena Lohrmann, Mahinda Mailagaha Kumbure, Pasi Luukka (LUT University, Finland), Yuri Lawryshyn (University of Toronto, Canada)*

Keywords: Supervised Feature Selection, Genetic Algorithm, Grey Wolf Optimization, Particle Swarm Optimization, Differential Evolution

Feature selection ensembles, which aim to obtain stable feature subset and, thus, contribute to the interpretability and reproducibility of results from a process including feature selection, have in recent years increased in popularity. The aim of this research work is to harness evolutionary and swarm intelligence-based methods that have demonstrated their ability to generate highly discriminating feature subsets as base selectors in feature selection ensembles. A comparison is conducted using genetic algorithms (GA), differential evolution (DE), grey wolf optimization (GWO), as well as particle swarm optimization (PSO) and following a data perturbation strategy for the feature selection ensemble. The results on two artificial and ten real-world data sets demonstrate that in many cases the stability of feature subsets can be improved significantly using an ensemble without deteriorating the classification accuracy of a learning algorithm on the subset.

WA2 Deep learning, Machine learning, and AI etc
Wednesday, August 23, 10:40~12:00, Room 323A
Chair: Fernando Gomide (University of Campinas, Brazil)

WA2-1   **Level Set Fuzzy Regression and Machine Learning**
(10:40 ~ 11:00)   *Fernando Gomide (University of Campinas, Brazil), Ronald Yager (Iona
College, USA)*

Keywords: Data driven level set, fuzzy modeling, ensemble and kernel machine learning

Linguistic and functional rule-based fuzzy modeling are two major paradigms of fuzzy systems. Level set fuzzy modeling is a third rule-based paradigm whose efficiency and capability to develop nonlinear controllers and data driven models have recently been reported in the literature. It has been shown that the performance of the data driven level set models outperform adaptive neurofuzzy, neural, rule-based, and autoregressive models. This paper revisits data driven level set modeling in front of strong machine learning regressors based on ensembles and kernels. The results show that the data driven level set fuzzy modeling surpass ensemble and kernel machine learning approaches.

WA2 Deep learning, Machine learning, and AI etc
Wednesday, August 23, 10:40~12:00, Room 323A
Chair: Fernando Gomide (University of Campinas, Brazil)

WA2-2   A Study of Processing Speed Index Prediction in Children with ADHD using (11:00 ~ 11:20)
Serious Game-Based Machine Learning
*Jun-Su Kim, Jeong-Heon Song, Byeong-Il Kim, Hyun-Suk Lee (Woorisoft Inc,
Korea), Byung-Jae Choi (Daegu University, Korea)*

Keywords: K-WISC, Processing Speed Index, Serious Game, Machine Learning, Prediction

Processing speed refers to the ability to perform simple tasks quickly and accurately while making decisions, and processing speed deficits are associated with neuro developmental disorders such as learning disabilities, attention deficit hyperactivity disorder, and autism spectrum disorder. In this study, a game-based assessment content was developed and clinical studies were performed to measure processing speed in order to identify the presence of such deficits at an early stage. In addition, a study was conducted to evaluate to predict the processing speed index score of the KWISC using performance data from the assessment content and three different machine learning models. The evaluation metrics used were MAE, RMSE, and R2_score. The results showed that the XGBoost model had the best prediction performance, with error rates of MAE=5.92, RMSE=7.85 and R2_score= 78.05%.

WA2 Deep learning, Machine learning, and AI etc
Wednesday, August 23, 10:40~12:00, Room 323A
Chair: Fernando Gomide (University of Campinas, Brazil)

WA2-3	**Survey on Recent Trends of Deep Learning-based Lane Detection Methods**
(11:20 ~ 11:40)	*Yun Hak Lee, Yeon Jeong Chae, Sung In Cho (Dongguk University, Korea)*

Keywords: Lane detection, Advanced driver assistance system, Autonomous driving

With the rapid growth of autonomous driving technology, deep learning-based lane detection method has become attractive research topic. In this paper, we address recent studies on lane detection. We divide deep learning-based lane detection methods into three categories: segmentation-based, parametric-based, and anchor-based methods. Then, we analyze each approach and explain their pros and cons. We provide experimental results on TuSimple dataset that is the most widely used in the lane detection fields. In addition, we analyze each approach by comparing the lane detection accuracy. Finally, we address the direction of the future research based on the experimental results.

WA2 Deep learning, Machine learning, and AI etc
Wednesday, August 23, 10:40~12:00, Room 323A
Chair: Fernando Gomide (University of Campinas, Brazil)

WA2-4	**Eigenvalue Distribution of Large Matrices with Randomness for Principal Component Analysis**
(11:40 ~ 12:00)	*Masaaki Ida (National Institution for Academic Degrees and Quality Enhancement of Higher Education, Japan)*

Keywords: Uncertainty, Random matrix, Eigenvalue distribution, Correlation analysis, Principal component analysis

In this paper, we consider the big data which is almost dominated by randomness, but also contains a small amount of important information. We consider the data with uncertainty based on Random Matrix Theory. We aim for the improvement of approximation for eigenvalue distribution of large matrices and its application to Principal Component Analysis.

Entani, Tomoe   MA1-2

Kang, Dongwoo   TB4-4
Kaymak, Uzay Kerk,   TA3-1
Yi Wen   MA2-4

-

-

Sikandar, Ali   WA1-3
Silpani, Dian Christy   LB-8
Sobirjon, Habibullaev   TB4-3
Son, Won Hee   TA2-1
Son, Yunsik   TB3-4, TB3-5
Sone, Yuka   TB3-2
Song, Doo Heon   TA2-1
Song, Jeong-Heon   WA2-2
Spruit, Marco   TA3-1
Srinivasan, Thiruvenkadam   MA2-2, MB4-3
Stoklasa, Jan   WB1-3
Stoklasová, Jana   WB1-3
Su, Shun-Feng   MB1-4, MB3-2
Sumon, Rashedul Islam   WA1-4

Sun, Wei   MB1-4
Svitek, Miroslav   TB2-2
Szilagyi, Laszlo   LB-5

T

Takenouchi, Hiroshi   MA4-2
Tao, Chin-Wang   MB4-1
Tay, Kai Meng   MA2-4
Theodore, Tagne Poupi   TA4-3
Timchenko, Victor L.   TB2-1
Tokuamru, Masataka   MA4-2
Tsai, Ching-Chih   MB1-2, MB1-3, MB2-4
Tsao, Hao-Han   MB4-2

U

Urenda, Julio   TB2-3

V

Venkatapathy, Sujitha   MB4-3

W

Wang, Le   MB1-4
Wasques, Vinicius F.   LB-2
Won, Byung-Sun   MA3-4
Woo, Jinseok   TB3-2
Woo, SeungHyun   TB3-5
Wu, Zheng   MA2-3

X

Xu, Xiaoran   MB4-4
Xu, You-Hao   MB2-1

Y

Z

Zervanou, Kalliopi
Zhang, Rui-Qian   TA3-1
Zhang, Zhongqun   MB4-1
Zou, ChangMan   TA4-4
                                MB2-3

Some Notes on Monotone TSK Fuzzy Inference Systems

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Abstract

This article presents our recent research on monotone Takagi-Sugeno-Kang (TSK) Fuzzy inference systems (FISs). We outline a few remarks on the necessary and sufficient conditions for TSK-FIS to be monotone, building upon the Ordered Weighted Averaging (OWA) principle and the orness concept. Some remarks for constructing monotone TSK-FIS from monotone data, extended from our previous findings, are further elucidated.

Keywords: Fuzzy Inference Systems, Ordered Weighted Averaging, data-driven monotone Takagi-Sugeno-Kang fuzzy model

1. Introduction

1.1 Background

Originated from Zadeh [1], reasoning with fuzzy If-Then rules have been popular and proven useful for over a few decades. A number of Fuzzy Inference Systems (FISs) have been widely applied to various applications, e.g., Mamdani FIS [2][3], Takagi-Sugeno-Kang (TSK)-FIS [4][5], and Tsukamoto FIS [6]. It is worth mentioning that a well-known challenge in FIS modelling is the presence of a sparse fuzzy rule base [7] [8], i.e., the fuzzy rule base contains insufficient information pertaining to its total state space.

In this article, we consider a class of FIS models with the monotonicity property between inputs and output. An FIS model, denoted as f, is known as monotone non-decreasing if the FIS output is increasing with respect to all combinations of the available input variables [9]. The use of FIS to approximate a monotone function, potentially from data samples, has been widely reported (see [12][13][14]). In this respect, the monotonicity property is important for FIS models to be aggregation functions [10][11].

1.2 Research Gap and Aim

The focus of the study is on monotone TSK-FIS models (see [9][12]-[16]). Several research gaps in this domain are outlined, as follows, along with six remarks presented in Sections 3 to 6.

i. The necessary condition of TSK-FIS to be monotone remains unsolved. The first aim of this study is to analyze and discuss the general necessary condition(s) of TSK-FIS to be monotone, as presented in Remarks 1 and 2. We clarify some specifications are NOT general necessary condition of TSK-FIS to be monotone at Remark 2.

ii. While monotone TSK-FIS is related to the Ordered Weighted Averaging (OWA) principle [19]-[21], it is unsure how. OWA has wide applicability due to its flexibility in modelling a family of parameterized averaging aggregation functions, in conjunction with the *orness* concept [19]-[21] and orness measure of an OWA [19]-[21]. From (i), it is unclear how the OWA principle and the orness concept can be utilized to derive a set of useful and a more general sufficient conditions. The second aim of this study is to analyze and outline a new sufficient condition for TSK-FIS to be monotone. Remarks 3, which considers the necessary condition from Remarks 1, is outlined.

iii. In addition to (i) and (ii), we define the necessary condition of TSK-FIS to be dense, deviating from TSK-FIS with a sparse fuzzy rule base. Remarks 4 and 5 are presented.

iv. We leverage monotone data to construct TSK-FIS from data samples. We explain some findings from our previous studies [13][17], and further elucidate the possibility of obtaining monotone fuzzy rules from non-monotone data.

v. In Section 6, Remarks 6 are presented for TSK-FIS to operate as an n-ary aggregation function.

Based upon a class of monotone dynamical systems [18], the new sufficient condition for TSK-FIS to model these monotone dynamical systems is derived.

2 Preliminary

2.1 Ordered Weighted Averaging and Orness

An OWA operator of m dimension is a mapping of $F: \mathbb{R}^m \to \mathbb{R}$ if it has an associated weight vector $\boldsymbol{w} = (w_1, \ldots, w_m)^T$ with $w_j \in [0,1]$ and $\sum_{j=1}^{m} w_j = 1$, such that $F(a_1, \ldots, a_m) = \sum_{j=1}^{m} w_j b_j$, where b_j is the jth largest element a_j. The weights w_j are associated with a particular ordered position b_j rather than with a particular element. An OWA operator is always commutative, monotonic and idempotent [20][21].

Orness of an m-ary OWA is increasing [19], i.e., $Or(\boldsymbol{w}_{(1)}) > Or(\boldsymbol{w}_{(2)})$, if two m-dimensional weight vectors, i.e., $\boldsymbol{w}_{(1)}$ and $\boldsymbol{w}_{(2)}$, satisfy $\boldsymbol{w}_{(1)} = (w_{1,(1)}, \ldots, w_{m,(1)})^T$ and $\boldsymbol{w}_{(2)} = (w_{1,(1)}, \ldots, w_{\xi} - \epsilon, \ldots, w_{\rho} + \epsilon, \ldots, w_{m,(1)})^T$, where $\epsilon > 0$ and $\xi < \rho$.

2.2 TSK-FIS Modelling

An TSK-FIS model with P fuzzy rules is considered, as follows. The input variable x_i from the input domain $X_i \in X \in \mathbb{R}^n$, $i \in \{1, .., n\}$ has $p_i \geq 1$ fuzzy membership functions (FMFs). Each FMF $\mu_i^{r_i}(x_i)$ is associated with a linguistic term $A_i^{r_i}$, where $r_i \in \{1, \ldots, p_i\}$ and $r_1, \ldots, r_n$ is an integer. A fuzzy rule is constructed in the form of

R^v: IF x_1 is A_1^v AND .... AND x_n is A_n^v THEN y is $y^v(x)$

An TSK-FIS model, namely $f: X \to Y$, is presented, as follows, where $A^v(\boldsymbol{x}) = \prod_{i=1}^{n} A_i^{r_i}(x_i)$ and $\overline{A^v(\boldsymbol{x})} = \frac{A^v(\boldsymbol{x})}{\sum_{v=1}^{P} A^v(\boldsymbol{x})}$. $A_0^{v\prime}$ is the support of $A^v(\boldsymbol{x})$. In addition, $y^v(\boldsymbol{x}|A_0^{v\prime})$ is a *restriction* of $y^v(\boldsymbol{x})$ to be $A_0^{v\prime}$.

$$f(\boldsymbol{x}) = \frac{\sum_{v=1}^{P} A^v(x) \times y^v(x)}{\sum_{v=1}^{P} A^v(x)} = \sum_{v=1}^{P} \overline{A^v(\boldsymbol{x})}\, y^v(\boldsymbol{x}) = \sum_{v=1}^{P} \overline{A^v(\boldsymbol{x})}\, y^v(\boldsymbol{x}|A_0^{v\prime})$$

3 Monotone TSK-FIS Modeling

An FIS model (i.e., $f: X \to Y$) is denoted as monotone non-decreasing if it satisfies $f\left(\boldsymbol{x}_{(1)} = (x_{1,(1)}, \ldots, x_{i,(1)}, \ldots, x_{n,(1)})\right) \leq f\left(\boldsymbol{x}_{(2)} = (x_{1,(2)}, \ldots, x_{i,(2)}, \ldots, x_{n,(2)})\right)$ for all $x_{i,(1)} \leq x_{i,(2)} \in X_i$,

$i \in \{1, \ldots, n\}$, in an n-dimensional input space $X \in \mathbb{R}^n$ and an output space, $Y \in \mathbb{R}$.

3.1 The necessary and/or sufficient conditions for TSK-FIS to be monotone

A mathematical condition for TSK-FIS to be monotone is denoted as *necessary* when it is impossible for TSK-FIS to be monotone without the said condition. If there exists a counter example for TSK-FIS to be monotone without the said condition, then the necessary condition is void. On the other hand, a mathematical condition for TSK-FIS to be monotone is denoted as *sufficient* when the said condition guarantees TSK-FIS to be monotone. Note that TSK-FIS can be monotone without the sufficient condition.

(a) The necessary conditions

We present and analyze several remarks as the necessary conditions to construct monotone TSK-FIS models.

Remark 1 Two necessary conditions

1.1. The summation of the firing strength from all fuzzy rules, i.e., $\sum_{v=1}^{P} A^v(\boldsymbol{x}) > 0$, for all $\boldsymbol{x}$ is a nessasacry condition. If there is an $\boldsymbol{x}$ such that $\sum_{v=1}^{P} A^v(\boldsymbol{x})=0$, $\overline{A^v(\boldsymbol{x})}$ is undetermined, e.g., 0/0 is undefined, then $f(\boldsymbol{x})$ is undetermined.

1.2. A fuzzy rule base should be complete, in the sense that all $y^v(\boldsymbol{x}|A_0^{v\prime})$ are defined and known. It is impossible to compute $f(\boldsymbol{x})$ for all $\boldsymbol{x}$ without knowing all $y^v(\boldsymbol{x}|A_0^{v\prime})$.

Remark 2 None-general necessary conditions

2.1. The specification for $A^v(\boldsymbol{x})$ *alone* at the antecedent part is NOT a necessary condition for designing monotone TSK-FIS models. If all $y^v(\boldsymbol{x})$ are identical for all v, then $y = f(\boldsymbol{x}) = y^v(\boldsymbol{x})$, is always true.

2.2. Monotone $y^v(\boldsymbol{x})$ at the consequent part alone is NOT a necessary condition for designing monotone TSK-FIS models. Since TSK-FIS can be reduced to $\sum_{v=1}^{P} \overline{A^v(\boldsymbol{x})}\, y^v(\boldsymbol{x}|A_0^{v\prime})$, it is possible to obtain a monotone TSK-FIS model without monotone $y^v(\boldsymbol{x})$.

2.3. A monotone fuzzy rule base, i.e., $y^{v(r_1, r_2, \ldots, r_n)_{(1)}}(\boldsymbol{x}) \leq y^{v(r_1, r_2, \ldots, r_n)_{(2)}}(\boldsymbol{x})$ such that $(r_1, r_2, \ldots, r_n)_{(1)} \leq (r_1, r_2, \ldots, r_n)_{(2)}$, for all $\boldsymbol{x}$, alone is NOT a necessary condition for designing monotone TSK-FIS models. If $\overline{A^v(\boldsymbol{x})}$ is identical for all $\boldsymbol{x}$, a non-monotone fuzzy rule base can produce a monotone TSK-FIS model.

(b) The sufficient conditions with a restriction on the maximal of two overlapping FMFs

Remarks 3 A sufficient condition based on a restriction of the maximal of two overlapping FMFs at X_i.

3.1 Remarks 1.1 and *1.2* are necessary conditions.

3.2 At the antecedent part of a fuzzy rule base, following the orness concept of an OWA operator, all $A_i^{r_i}(x_i)$ are designed such that orness of the vector consisting of r_i numerals, i.e., $\left(\overline{A_i^1(x_i)}, \overline{A_i^2(x_i)}, \dots, \overline{A_i^{p_i}(x_i)}\right)$, increases when x_i increases.

3.3 At the consequent part of a fuzzy rule base, all $y^v(\boldsymbol{x}|A_0^{v\prime})$ are monotone, i.e., $y^v\left(\boldsymbol{x}_{(1)}|A_0^{v\prime} = \left(x_{1,(1)}, \dots, x_{i,(1)}, \dots, x_{n,(1)}\right)\right) \leq y^v\left(\boldsymbol{x}_{(2)}|A_0^{v\prime} = \left(x_{1,(2)}, \dots, x_{i,(2)}, \dots, x_{n,(2)}\right)\right)$ for all $x_{i,(1)} \leq x_{i,(2)} \in X_i$, and all v , $i \in \{1, \dots, n\}$, but $y^v(\boldsymbol{x})$ may not be monotone at is entirety.

Note that the proposed set of sufficient conditions is restricted to the case that the maximal of two FMFs overlap each other at X_i. If **Remarks 1.1** and **1.2** are always true, valid $\sum_{v=1}^{P} \overline{A^v(\boldsymbol{x})}$ and $y^v(\boldsymbol{x}|A_0^{v\prime})$ can always be obtained.

Condition 3.2 ensures that a valid vector of orness with p_i- numerals i.e., $\left(\overline{A_i^1(x_i)}, \overline{A_i^2(x_i)}, \dots, \overline{A_i^{p_i}(x_i)}\right)$, always increases, if x_i increases. There are only two $\overline{A_i^{r_i}(x_i)}$ greater than zero, and all others are zeros. In addition, Condition 3.3 ensures that $y^{v(r_1, r_2, \dots, r_n)(1)}(\boldsymbol{x}) \leq y^{v(r_1, r_2, \dots, r_n)(2)}(\boldsymbol{x})$ is always true, for each $\boldsymbol{x}_{(1)} \leq \boldsymbol{x}_{(2)}$ and $(r_{1,(1)}, r_{2,(1)}, \dots, r_{n,(1)}) \leq (r_{1,(2)}, r_{2,(2)}, \dots, r_{n,(2)})$. Deduced from the OWA properties, the resulting TSK-FIS model is always monotone.

4. Sparse and Dense TSK-FIS Modelling

From the conditions in Section 3, it is possible for us to define sparse [25] and dense [25] TSK-FIS models.

Remark 4 An TSK-FIS model is denoted as *dense* if and only if Remarks 1.1 and 1.2 are true; otherwise it is *sparse*.

If Remarks 1.1 and 1.2 are true, we can always obtain $\sum_{v=1}^{P} A^v(\boldsymbol{x}) > 0$ and $y^v(\boldsymbol{x}|A_0^{v\prime})$. For any $\boldsymbol{x}$, a fuzzy rule(s) can always be fired, and valid $f(\boldsymbol{x})$ can be obtained. If either Remarks 1.1 or 1.2 is not true, not all $f(\boldsymbol{x})$ can be obtained.

Remarks 1.1 and 1.2, together with Remark 4, suggest that dense TSK-FIS is necessary for constructing a monotone TSK-FIS model. If Remarks 1.1 and 1.2 are not satisfied, fuzzy rules interpolation [7] [8] [25] coupled with the monotone condition [26] is necessary.

5. Monotone data meeting Monotone TSK-FIS

5.1 Monotone data

Definition 1 [13]: Consider a set of input-output data samples, i.e., $(\boldsymbol{x}^p; y^p), p \in [1, 2, \dots, h]$, where output $y^p \in Y$ is influenced by the input of n variables, $\boldsymbol{x}^p = [x_1^p, x_2^p, \dots, x_n^p] \in X_1 \times X_2 \times \dots \times X_n$ based on the data set. A data sample, y^q, is further considered, where $q \in [1, 2, \dots, h]$ and $q \neq p$.

(i) Two notions are defined, as follows.
$\underline{y^q} = \max\{y^p |$ all samples $p \neq q$ for which $x_i^p \leq x_i^q, i = 1, \dots, n\}$

$\overline{y^q} = \min\{y^p |$ all samples $p \neq q$ for which $x_i^p \geq x_i^q, i = 1, \dots, n\}$

(ii) The data set is *monotone* if $\underline{y^q} \leq y^q \leq \overline{y^q}$ is true for all $q = 1, \dots, h$. Otherwise, the data set is *non-monotone*.

Remarks 5 If the data set is *monotone*, it is possible to approximate a monotone function fitting the data set with zero error.

5.2 Additional remarks

In our previous studies [13][14], we have indicated that monotone data do not always produce monotone fuzzy rules in monotone TSK-FIS modelling. In this article, we further explain that a set of non-monotone data samples can produce monotone fuzzy rules using a typical data-driven FIS modelling method, i.e., the Wang and Mendel (WM) method [24].

Here, a simulated example consisting of a total of nine input-output data pairs to construct a single-input single-output TSK-FIS model is considered. The non-monotone data-pairs $D = \{\boldsymbol{x}^p; y^p\}_{k=1}^9$ are depicted in Fig.1. Three trapezoidal FMFs denoted as $\mu_i^{r_i} = (a, b, c, d)$ are used, where $\mu_1^1 = (0,0,1,2)$, $\mu_1^2 = (1,2,3,4)$, and $\mu_1^3 = (3,4,5,5)$, as shown in Fig. 2. With the WM method [24], monotone fuzzy rules are obtained, where $\{y^v\}_1^3 = (0.8333, 6.5381, 16.6667)$. A monotone surface plot for the resulting TSK-FIS output is shown in Fig. 3.
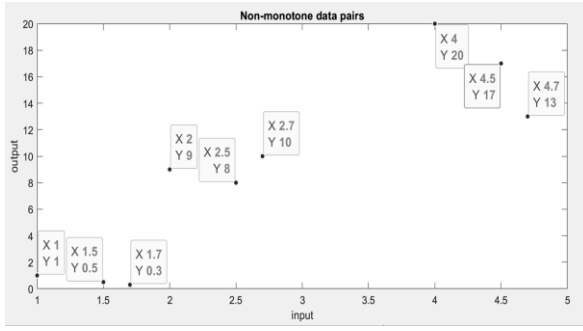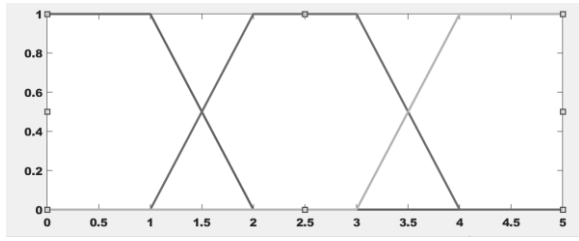
Fig. 1. Non-monotone input-output pairs

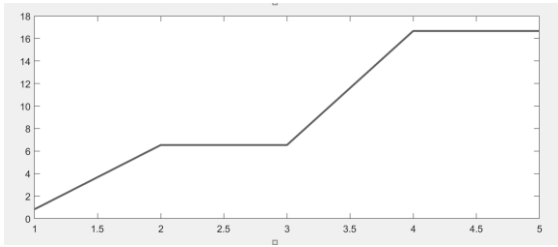Fig. 2. The design of trapezoidal fuzzy membership functions

Fig. 3. TSK-FIS output obtained using the Wang-Mendel method

6. TSK-FIS as an *n*-ary aggregation function

From [14], and extending from Remarks 3, a set of new sufficient conditions for TSK-FIS to operate as *n*-ary aggregations functions is outlined. As follows.

Remarks 6 A sufficient condition for TSK-FIS to operate as an *n*-ary aggregation function.

6.1 Satisfactions of Remarks 3.1 and 3.2

6.2 y^v ($0,0,0,\dots 0$)=0, for all v such that $\overline{A^v(0,0,0,..0)} > 0$.

6.3 y^v ($1,1,1,\dots 1$)=1, for all v such that $\overline{A^v(1,1,1,..1)} > 0$.

With Remarks 6.1, the resulting TSK-FIS model is always monotone. With Remarks 6.2 and 6.3, the boundary conditions pertaining to $f(0,0,0,\dots 0) = 0$ and $f(1,1,1,\dots 1) = 1$ are always true.

7. Discussion and Conclusion

In this article, several research gaps pertaining to state-of-the-art monotone TSK-FIS models (see [9][12]-[16]) have been discussed and analyzed. We have explained the necessary and sufficient conditions for TSK-FIS to be monotone, building upon the OWA principle and orness concept. Extended from our previous findings, we have also shown that non-monotone data samples can produce monotone fuzzy rules using a typical data-driven FIS modelling method. We also presented the sufficient conditions for TSK-FIS to operate as *n*-ary aggregations functions.

From [18], a class of monotone dynamical systems with three types of monotonicity characteristics was reported, i.e., *monotone*, *strictly monotone* and *strongly monotone*. We consider that semiflow, Φ_t, in an ordered space of X and Φ_t, is monotone if $\Phi_t\left(x_{(1)} = (x_{1,(1)}, \dots, x_{i,(1)}, \dots, x_{n,(1)})\right) \leq \Phi_t\left(x_{(2)} = (x_{1,(2)}, \dots, x_{i,(2)}, \dots, x_{n,(2)})\right)$ for all $x_{i,(1)} \leq x_{i,(2)} \in X_i$, $i \in \{1, \dots, n\}$, and $t > 0$. Remark 3 is a set of sufficient conditions to model Φ_t, if TSK-FIS is employed.

As future works, inspired from [27] [28] [29], monotone TSK-FIS, with a learning algorithm, and their sufficient conditions to operate as *n*-ary *conjunctive*, *disjunctive*, and *mixed* aggregations functions, *t*-norm and *t*-conorm, as well as, as *n*-ary *fuzzy connectives*, will be outlined. As such, applications of the new sufficient conditions, to real world applications, for example Failure Mode and Effect Analysis (FMEA) [30], will be explored.

Acknowledgement

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