A Study on Abstract Meaning Representation

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1 Research Content

Humans are born with the ability to communicate with their natural language. Computing machines, on the other hand, only understand several specific programming languages, with a limit of expressions. To bridge the gap between humans and computers languages, semantic representation is one such a solution, with the ability to convert natural language utterances into machine-understandable forms. Many semantic schemes have been introduced and developed, such as Combinatory Categorial Grammar (CCG), Groningen Meaning Bank (GMB) or Abstract Meaning Representation. Two traditional problems of semantic representations are producing them from natural language (parsing) as well as producing natural language from them (generation). In this thesis, we present our study in Abstract Meaning Representation (AMR) Parsing and Generation, which are showing lots of potential in computational linguistics community recently. We also present our first attempt on the domain adaptation in parsing and generation for legal text.

In the first part of our thesis, we present our AMR-to-text generator incorporating the self-attention mechanism. Motivated by the domination of the Transformer architecture in various Natural Language Processing tasks, e.g. machine translation, text summarization, we adopt its core component - the self-attention - to build our generation models. We conduct experiments on both sequence to sequence and graph to sequence strategies, which are dominating in solving this problem. Our proposed method obtains competitive results on a benchmark AMR dataset, with an improvement of 3.2 BLEU score over the baseline sequence-to-sequence model.

Despite several developments in AMR parsing and generation for text in general domain, current methods for these tasks still struggle in dealing with the legal domain. The legal text is often structurally complicated, consists of longer sentences and contains specific terminologies that are rarely seen in general-domain text. This also causes lots of difficulties in natural language understanding in general, and AMR parsing in our study. In the second part of our thesis, we provide a literature survey over different methods in AMR parsing and show their performances on analyzing legal documents. We conduct empirical experiments

of various AMR parsers on a benchmark AMR dataset with various ranges of sentence length, and our annotated legal dataset. Our results show the current limitations and also open a room for improvements of current parsing techniques for legal domain adaptation.

For the generation direction, we observe that text generated from AMR using current deep learning models usually become awkward with lots of "out of vocabulary" tokens. In the second part of our thesis, we propose some modifications in the training and decoding phase of the encoder-decoder AMR generation model to have a better text realization. Our model is tested using an annotated legal dataset extracted from the English version of the Japanese Civil Code, showing an improvement compared to the baseline model.

To summarize, our study in AMR parsing and generation along with the legal domain adaptation contribute to the literature of semantic representation. Despite some improvements and findings, our work still remains specific drawbacks. Since our first results are still preliminary, we figure out several ideas to improve our performance in the future.

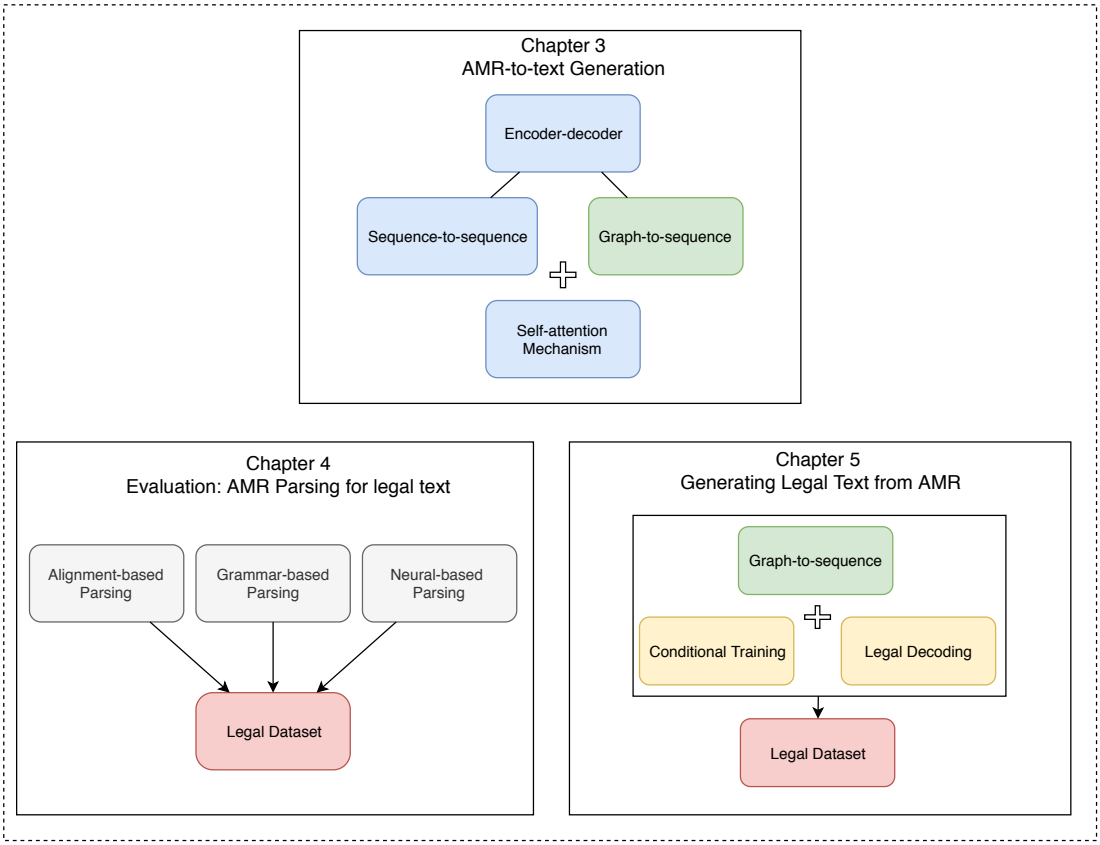

Figure 1: Dissertation Outline

Keywords: **Abstract Meaning Representation**, **Deep Learning**, **Semantic Parsing**, **Legal Domain**, **Text Generation**.

2 Research Purpose

The main contributions of this dissertation can be summarized as follow:

- **Legal Dataset JCivilCode** : We extract the first four chapters in the Japanese civil code (in English version) and manually annotate in the format of AMR. This is the first AMR dataset in legal domain, rather than popular datasets in general domain. Though the number of samples is still small, this dataset helps develop the research in domain adaptation in legal domain. We conduct experiments of different AMR parsers in three main parsing approaches on our annotated dataset to see the quality of legal text parsing. Our results show the difficulties as well as suggest several ideas for future improvement in AMR parsing for legal documents.

- **Self-attention text generation from AMR graphs**: We propose a transformer approach in converting an AMR graph into a natural language sentence. We incorporate the self-attention mechanism into the encoder-decoder model in both sequence to sequence and graph to sequence strategies. Evaluating by a benchmark dataset, our method obtains comparative results comparing to existing neural models in the literature.

- **Legal Style Text Generation**: We propose two modifications in the training and decoding phase of the neural graph to sequence AMR generation model. With these modifications, we provide more legal-related constraints for generating text from an input legal AMR. We then finetune our models using a silver annotated dataset in legal domain. The experimental results prove the effectiveness of our method over the baseline model.

Based on promising results of this thesis, we figure out some future works:

- Data augmentation: Training data play an important role in training deep neural network models for both parsing and generation. To obtain more high-quality legal data, we need to discover some data augmentation techniques, i.e. data recombination strategy that generate new AMRs from current pair of (sentence, AMR) based on heuristic rules.

- Logical complexity: as mentioned in two chapters of this dissertation, this complexity causes lots of errors for both AMR parsing and generation models. Several research have been proposed to generate logical forms from text and entities graph recently. We plan to explore these works to build a logical attention mechanism to capture these information more effetively.

- AMR applications: we plan to apply AMR in several downstream problems such as Legal Question Answering. Despite the capablity of AMR in expressing the "who is doing what to whom" aspects, there are not many works investigate the application of AMR in question answering (QA), especially for legal domain. We expect our legal dataset can be enlarged and contributes to a legal QA system.

3 Research Accomplishment

[1] Vu Trong Sinh and Le Minh Nguyen. A study on self-attention mechanism for amr-to-text generation. In *Natural Language Processing and Information Systems - 24th International Conference on Applications of Natural Language to Information Systems, NLDB 2019, Salford, UK, June 26-28, 2019, Proceedings*, pages 321–328, 2019. doi: 10.1007/978-3-030-23281-8_27. URL `https://doi.org/10.1007/978-3-030-23281-8_27`.

[2] Vu Trong Sinh and Nguyen Le Minh. An empirical evaluation of amr parsing for legal documents. In *New Frontiers in Artificial Intelligence JSAI-isAI 2018 Workshops, JURISIN, AI-Biz, SKL, LENLS, IDAA*, pages 131–145, Yokohama, Japan, 2018.

[3] Lai Dac Viet, Vu Trong Sinh, Nguyen Le Minh, and Ken Satoh. Convamr: Abstract meaning representation parsing for legal document. *arXiv preprint arXiv:1711.06141*, 2017.

[4] Vu Trong Sinh, Nguyen Le Minh, and Satoh Ken. Legal text generation from abstract meaning representation. In *Proceedings of the 32nd International Conference on Legal Knowledge and Information Systems*, Madrid, Spain, 2019.

[5] Vu Trong Sinh, Nguyen Le Minh, and Satoh Ken. Abstract meaning representation for legal documents. *submitted to the Journal of Artificial Intelligence and Law - Springer Nature*, 2020.

Demand-Side Management in Residential Community Energy System for the Smart Grid

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1. Research Content

The electrical grid has operated on a centralized, top-down model for the past century and heavily relied on fossil fuels for energy production. Grid operators are responsible for the reliable delivery of electricity to consumers where electricity generation must be matched with the total demand at all times. The main driving costs and capacity requirements are the electricity demand that occurs during peak periods. These peaks in demand require utility companies to operate costly and inefficient generators. Moreover, a concern of climate change and greenhouse gas emission leads to an expected widespread demand-side adoption of distributed energy resources (DERs), including renewable energy. The higher penetration of renewable energy resources causes the challenges of the grid operators to exacerbate. The intermittent nature of renewable resources and uncoordinated operation of DERs substantially limit the ability of the supply adaptation to the fluctuating demand and reverse power flow. One of the foreseeable solutions is to manage how end-users consume their energy. Demand-side management (DSM) is a technique to exploit the flexibility in the demand-side and change the consumption pattern of the end-users such that demand profiles match better with the supply and thus lower energy costs.

In this research, a DSM method for a residential community with high penetration of DER is proposed. In the proposed DSM method, a local energy sharing scheme is incorporated into a price-based demand response (DR) to exploit the value of DER, benefiting both the utility company and its customers. On the one hand, the utility company can adopt the DSM method to motivate the customers to shift their energy consumption and production such that peak demand and export energy can be reduced. As a result, the aggregate consumption curve becomes flatter and smoother. Therefore, the utility company can lower energy costs from the costly peak-time energy procurement and mitigate the problem of reverse power flow. On the other hand, the customers will be incentivized from participating in DSM and motivated to

share their excess energy locally. Thus, increasing their energy bill savings and self-consumption, which maximize the value of DER.

The proposed DSM method is evaluated in a residential community by simulations. The residential community is populated with a number of houses with different consumption profiles and preferences. Different household consumption and generation profiles are synthetically generated using a publicly available domestic electricity demand generation tool which statistically validated with real-world measured consumption data while household appliances and a battery are modeled based on commercial device specification data. The simulation results indicate the effectiveness of the proposed DSM model in terms of peak demand and export energy reduction while maximizing the energy bill savings of the users. Simulation on the impact of battery, PV generation, and user participation in the system performance is also carried out. Furthermore, the simulation results of the proposed consumption rescheduling algorithm show improved consumption profile of the community in response to the changing preferences of users. Finally, the results of the proposed energy billing mechanism show a fair allocation of energy bills to each user proportion to the amount of deviated energy consumption from the assigned schedules.

2. Research Purpose

In order to design a DSM method for high penetration of DER in the residential community, proper designs of energy price functions and interaction among entities are required. We design a procedure for the proposed DSM into three sequential steps: day-ahead consumption scheduling, consumption rescheduling, and energy billing.

- In the day-ahead consumption scheduling step, each house in the community plans energy consumption for the next day to minimize energy cost based on proposed dynamic energy prices. The existing research has failed to design the price signals to encourage the use of DER and mainly focused on the aggregate energy consumption profiles while the full potential value of generated DER energy is still yet to exploit. Noticing these shortcomings, we propose a DSM model that taking into account various types of DER and exploiting the possibility of managing the generated DER energy more efficiently. Inspired by the works in local energy sharing research, we notice the potential to share the DER energy locally and leverage the benefit of DER. The proposed DSM model incorporates local energy sharing mechanism with the price-based DR. We propose local energy price functions that depend on the dynamic of both grid condition and local DER and aim to encourage users to change their consumption patterns to align with the system objectives, e.g., reducing peak demand and export energy, while maximizing energy bill savings of the users by sharing energy locally. Then, an energy bill minimization problem for each user is formulated for consumption scheduling based on appliance specifications and preferences. Finally, we present an iterative distributed algorithm to solve for optimal consumption schedules while preserving the privacy of the users.

- In consumption rescheduling step, we consider uncertainty in human behavior and commitment to the assigned day-ahead consumption schedules. We propose a consumption rescheduling algorithm to cope with such uncertainty which executes during operation periods. The proposed consumption rescheduling algorithm allows users to request for change and recalculate the consumption schedule in order to minimize the impact of the uncertainty on the overall system and their energy bills. The consumption rescheduling algorithm lets the user who changes his preference to recalculate the consumption schedule while other users kept their assigned schedule unaffected, preventing from frequent schedule alternation.
- In the energy billing step, we consider improving the fairness of energy billing among users in the community at the end of each day. A DSM program which treats the participating users fairly would be able to maintain active participation and able to exploit the available flexibility to its full capacity, while the program with lack of fairness could discourage the users from participating in the DSM activity and possibly opt-out from the program. Considering the fairness criterion, we notice that the realized energy consumption could deviate from the optimal assigned schedules and cause an unfair energy bill distribution to the users in the community. Thus, we propose an alternative fair billing mechanism for our DSM model. Since we considered the residential community with high penetration of DER, where energy consumption could deviate in both upward and downward directions, we introduce penalty and reward allocation based on the user's violation and commitment in the proposed billing mechanism to fairly address any billing discrepancy proportionally to the user's behavior.

The proposed DSM model provides a possibility for utility companies with a solution to manage the energy consumption of residential users with DER. Thus, reduce the cost of balancing supply and demand by flattening demand curves. For the energy end-users, the proposed DSM model provides the opportunity to increase financial benefits and investment returns for their DER. Thus, exploiting the full value of DER through local energy sharing and DSM. Also, the proposed consumption rescheduling algorithm and fair billing mechanism improve the practicality of the DSM considering uncertainty from human behavior and schedule violation. Furthermore, the proposed DSM model is essential for facilitating the integration of DER toward the decentralization of the future electrical grid. Thus, help reduce global greenhouse gas emission and fight against climate change.

Keywords: *Demand-Side Management, Distributed Energy Resource, Energy Consumption Scheduling, Local Energy Sharing, Smart Grid*

Research Accomplishment

Journals

1. P. Charoen, S. Javaid, M. Sioutis, Y. Lim and Y. Tan, “Dynamic Pricing with Local Energy Sharing in Demand-Side Management,” *IEEE Transactions on Smart Grid* (submitted, under review)

2. P. Charoen, M. Sioutis, S. Javaid, C. Charoenlarpnopparut, Y. Lim, and Y. Tan, “User-Centric Consumption Scheduling and Fair Billing Mechanism in Demand-Side Management,” *Energies*, vol.12, no.1, pp. 156, 2019. (IF: 2.707)

International Conference papers (With Peer Review)

3. P. Charoen, S. Javaid, M. Sioutis, Y. Lim and Y. Tan, "Demand-Side Management with Local Energy Sharing Model for Prosumer Communities,” 9th International Conference on Power and Energy System (ICPES), Perth, Australia, 2019. (Accepted for publication)

4. P. Charoen, M. Sioutis, S. Javaid, Y. Lim and Y. Tan, "Fair Billing Mechanism for Energy Consumption Scheduling with User Deviation in the Smart Grid,” 6th International Conference on Smart Energy Grid Engineering (SEGE), ON, Canada, 2018, pp. 84-88.

5. P. Charoen, S. Javaid, Y. Lim, Y. Tan and C. Charoenlarpnopparut, "Adaptive Rescheduling of Energy Consumption Based on User Preferences for the Future Smart Grid," IEEE PES Innovative Smart Grid Technologies - Asia (ISGT-Asia), Singapore, 2018, pp. 36-41.

Domestic Conference papers (Without Peer Review)

6. P. Charoen, S. Javaid, Y. Lim and Y. Tan, “Demand side management for the future smart grid,” JAIST World Conference (JWC), Ishikawa, Japan, 2018.

Personal Thermal Comfort Model for Cyber-Physical Human Centric Framework in Smart Homes

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1. Research Content

The current human society faces many problems, such as greenhouse gas (GHG) emissions, depletion of resources, and aging of the population. Future human centric society is that balances economic advancement with the resolution of social problems, and that is a system that highly integrates cyberspace and physical space using new technologies, such as the Internet of Things (IoT), Cyber-Physical Systems (CPS), and Artificial Intelligence (AI). In another view, the human centric society (HCS) understood as a smart and skilled operator who performs not only cooperative work with robots but also work aided by machines as and if needed by means of human CPS, advanced human-machine interaction technologies and adaptive automation towards achieving human-automation symbiosis work systems. To realize our future society, it is also essential to look at the mimic of a future society in the field of smart homes, which is the best practice for the viewpoint of system implementation of the CPS approach with human centric module.

The most central place of life and work scenes of HCS is the home environment that provides a safe living environment and comfort for the residents to meet people's physical and psychological needs. Smart Homes use the computation technology, the sensing technology, and the control technology to provide comfort and energy saving. The Cyber- Physical Home System (CPHS) comprises a smart system for a variety of services and applications in the home environment to provide home automation control, especially for the aims of comfortability and energy savings. Thermal comfort is an assessment of one's satisfaction with the environment surroundings. Personal satisfaction of thermal comfort is affected by many factors belongs the human centric domain.

CPS is the core technology to implement the HCS system. There is deep interaction between the cyber world and the physical world. CPHS is one of the most valuable domains for CPS applications. For future HCS system, the human has deep interaction of the cyber world and the physical world. However, several significant problems need to be solved in the CPS-based human centric system, the first is the computation problem, which is current CPS system does not consider the human centric, which leads to the event-driven task, the usage of time-delay model in the CPS system cannot meet the human demands and needs. The second problem is human centric model is generalized by a group of people, in which the control methods that use this model still cannot achieve the best target set for an individual. The third problem is that the CPHS is successfully verified and implemented, but this system cannot meet the thermal comfort of user preference. Personal thermal comfort should be pointed out to address this problem.

The vision of this dissertation is to propose a Cyber-Physical Human Centric framework and to implement its Cyber-Physical Human Centric system with the personal thermal comfort model. To accomplish this vision, three research objectives in this dissertation are proposed.

2. Research Purpose

To implement the proposed framework, following subtasks must be accomplished:

- First, this dissertation is to propose a ***Cyber-Physical Human Centric (CPHC)*** framework by focusing on the deep interaction between the human centric and CPS application, the human centric control, and the implementation of human centric CPS system application. The current CPS model is designed fundamentally for the system of systems, and it does not consider the human factor. Aiming the CPS computation problem, which leads to the consideration of the event-driven task, the usage of the time-delay model in the CPS system cannot meet the mixed requirement of time-driven and event-driven tasks scheduling. To mitigate this problem, I propose a new time task model with two algorithms, i.e., a mixed time cost and deadline first (MTCDF) algorithm, and a human-centric MTCDF algorithm into the CPHC Framework. The problem of scheduling success rate under different mixed requirements is discussed. The success rate of multi-requirement scheduling reached ***100%***.
- Second, the control module is one of the essential modules in the CPS system to ensure the entire system operates according to the achievable target set. Most of the CPS system is designed to meet a single target value or multiple target values of the system. Although many control methods, e.g., conventional PID and MPC, are proposed not only to minimize the processing time of the controller to achieve the target set but also to ensure the high accuracy of the controller. However, those control methods do not consider the human centric module due to the difficulties of modeling human factors. As mentioned in the previous research works, the human factor model is generalized by a group of people, in which the control methods that use this model still cannot achieve the best target set. In this dissertation, a generalized thermal comfort model is focused first. Based on the collected data, a ***personal thermal comfort (PTC)*** model is derived. Since the PTC is a comprehensive evaluation influenced by complex factors and random variables, it is difficult to apply the results in the real environment of the smart homes. With the development of IoT technology, a wearable device becomes our daily objects and also have the advantage of connected to the service platforms. This means that the measured data can be personalized. In this dissertation, a well-known wearable device is used to measure human heart rate, then the heart rate, heat sensation, environmental parameters, and so on as inputs into the artificial neural network (ANN) model for predicting the PTC model. In this dissertation, the PTC model is proposed and extend the existing energy efficient thermal comfort control (EETCC) system to achieve a better thermal comfort sensation while saving more energy. Through these, the differences between system computation and human needs are determined, then provide necessary for improving the personal thermal comfort control system. Besides that, the physiology parameter from the heart rate is well-studied, and its correlation with the environmental factors, i.e., PMV, airspeed, temperature, and humidity, are deeply investigated to reveal the human thermal comfort level of the existing system in the smart home environment. In the first stage, ***6*** participants conducted experiments, including heart rate data collection, environmental parameter collection, and subjective thermal comfort data collection. A total of ***16 data sets***, ***11520 samples*** were collected.

- Third, although the EETCC system is successfully verified and implemented in the iHouse environment, the thermal comfort of a resident does not be considered by the EETCC system. Notably, the personalization character of the PTC model with an artificial neural network (ANN), long short-term memory (LSTM) deep learning technique, which is not considered either. In this dissertation, the challenges of the EETCC/PTC are focused on achieving both high accuracy and high energy efficiency. In this way, the CPHC framework can be verified for its implementation with a human centric module. And this dissertation the improving the personal thermal sensation and reducing energy consumption through the experiments with CPHC system Implementation of smart home in the winter season. In the second stage, ***10*** participants conducted experiments, including heart rate data collection, environmental parameter collection, and subjective thermal comfort data collection. A total of ***40 data sets***, ***24000 samples*** were collected. In the morning session, the EETCC/PTC is made the ***68.4%*** in comfort zone, ***31.6%*** in the warm zone, and ***0%*** in cool zone. The EETCC is made 14.4% in cool zone. In the afternoon, the EETCC/PTC is made the ***53.6%*** in comfort zone and ***46.2%*** in the warm zone. The EETCC is made 35.1% in the warm zone. The performance of EETCC/PTC models is the highest accuracy is ***0.99702***. For subjective comfort level, the EETCC/PTC is improved ***6.7%*** than the first stage without PTC.

Keywords: *human centric society, cyber-physical system, smart homes, time task model, cyber-physical human centric framework, personal thermal comfort, energy efficient and thermal comfort control, heart rate predication, artificial neural networks.*

Publications and Awards

Journals

1. **Fang Y.**, Lim Y., Ooi S.E., Zhou C., and Tan Y., "Study of Human Thermal Comfort for Cyber-Physical Human Centric System in Smart Homes,", Sensors, MDPI, vol. 20, no. 2: 372, 2020 **[SCI, IF: 3.031]**
2. **Fang Y.**, Lim Y., and Tan Y., "Personal Thermal Comfort Prediction Model Based on Neural Network in Cyber-Physical Home Systems,", Internet of Things: Engineering Cyber Physical Human Systems, Elsevier, 2020 **(Submitted, under review)**
3. Wang W., Nagai Y., **Fang Y.**, and Maekawa M., "Interactive Technology Embedded in Fashion Emotional Design: Case Study on Interactive Clothing for Couples," International Journal of Clothing Science and Technology, vol. 30, no. 2, pp. 302-319. 2018 **[SCI, IF: 1.501]**
4. Wang W., **Fang Y.**, Nagai Y., Xu D., and Fujinami, T. "Integrating Interactive Clothing and Cyber-Physical Systems: A Humanistic Design Perspective," Sensors, MDPI, vol. 20, no. 1: 127, 2020 **[SCI, IF: 3.031]**

International Conference papers

5. **Fang Y.,** Lim Y., Ooi S.E., and Tan Y., "Time Task Scheduling for Simple and Proximate Time Model in Cyber-Physical Systems," Computational Science and Technology, Lecture Notes in Electrical Engineering (LNEE), Springer, Singapore, vol. 481, pp. 185-194, 2018
6. **Fang Y.,** Wang W.Z., Ooi S.E., Lim Y., and Tan Y., "Towards Smart Lighting Modeling of Cyber Physical Systems," 11th Asia Lighting Conference, pp.45-49. 2018
7. Ooi S.E., **Fang Y.**, Lim Y., and Tan Y., "Study of Adaptive Model Predictive Control for Cyber-Physical Home Systems," Computational Science and Technology, Lecture Notes in Electrical Engineering (LNEE), Springer, Singapore, vol. 481, pp. 165-174, 2018

Japan Domestic Conference papers

8. **Fang Y.**, Lim Y., and Tan Y., "Personal thermal comfort prediction model in cyber-physical home system," IEICE IN Conference, Okinawa, Japan, vol. 119, no. 461, pp. 127-130, Mar. 2020
9. **Fang Y.**, Ooi S.E., Lim Y., and Tan Y., "A human-centric time task scheduling for cyber- physical home system," IEICE ASN Conference, Tokyo, Japan, vol. 118, no. 468, pp. 127-130, Mar. 2019
10. **Fang Y.**, Li C., Tan Y., and Lim Y., "Simple and proximate time model framework of cyber-physical systems," IEICE ASN Conference, Oita, Japan, vol. 117, no. 426, pp. 109-114, Jan. 2018
11. **Fang Y.**, Ooi S.E., Lim Y., and Tan Y., "Towards machine learning of time task scheduling in cyber-physical systems," IEICE Society Conference, Kanazawa Univ., BS-7-10, S-45, Sep. 2018
12. Ooi S.E., Makino Y., **Fang Y.**, Lim Y., and Tan Y., "Study of predictive thermal comfort control for cyber-physical smart home system," IEICE ASN Conference, Oita, Japan, vol. 117, no. 426, pp. 29-34, Jan. 2018

Awards

A. Emerald Literati Awards for Excellence Highly Commended "Interactive Technology Embedded in Fashion Emotional Design: Case Study on Interactive Clothing for Couples," International Journal of Clothing Science and Technology, Apr. 2019

B. Student Best Paper Award "Towards Smart Lighting Modeling of Cyber-Physical Systems," 11th Asia Lighting Conference, Kobe University, Sep. 2018