ปธ.๐๐๑/๖๓

# บันทึกข้อความ

**ส่วนงาน** คณะวิทยาศาสตร์ หลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาเทคโนโลยีสารสนเทศ โทร 3900
**ที่** อว 69.5.8/041 **วันที่** 10 มีนาคม 2564
**เรื่อง** ขอรายงานสรุปเนื้อหาและการนำไปใช้ประโยชน์

**เรียน** คณบดีคณะวิทยาศาสตร์

ตามบันทึกข้อความที่ อว 69.5.8/002 ลงวันที่ 6 มกราคม 2564 ได้อนุญาตให้ข้าพเจ้าเข้าร่วมประชุมวิชาการระดับนานาชาติ "The ๖th International Conference on Digital Arts, Media and Technology (DAMT) and ๔th ECTI Northern Section Conference on Electrical Electronics, Computer and Telecommunications Engineering (NCON)" ECTI DAMT and NCON ๒๐๒๑ พร้อมเสนอผลงานทางวิชาการ และตามบันทึกข้อความที่ อว 69.5.8/014 ลงวันที่ 1 กุมภาพันธ์ 2564 ได้อนุญาตให้เปลี่ยนแปลงรายละเอียดในการเข้าร่วมประชุมวิชาการระดับนานาชาติและเสนอผลงานทางวิชาการเป็นการเข้าร่วมประชุมวิชาการ และนำเสนอผลงานผ่านช่องทางออนไลน์ นั้น

บัดนี้ ข้าพเจ้าได้เข้าร่วมนำเสนอผลงานวิชาการ ณ งานประชุมวิชาการ ECTI DAMT and NCON 2021 เป็นที่เรียบร้อยแล้ว ดังนั้นจึงขอรายงานสรุปเนื้อหาและประโยชน์ที่ได้รับ ดังนี้

1. สรุปเนื้อหาที่ได้รับจากการเข้าประชุม/อบรม ฯลฯ

จากการเข้าร่วมประชุมวิชาการครั้งนี้ได้รับความรู้ที่สามารถนำมาพัฒนาความเชี่ยวชาญของตนเอง ในด้านระบบการให้คำแนะนำ ในการเข้าร่วมครั้งนี้ได้ส่งผลงานวิชาการเข้าร่วมตีพิมพ์เผยแพร่ในหัวข้อเรื่อง Alternative-Ingredient Recommendation Based on Thai Recipe วัตถุประสงค์ของงานวิจัยนี้ ต้องการช่วยเหลือผู้ประกอบอาหารไทยทั้งชาวไทยและชาวต่างประเทศสามารถประกอบอาหารไทยได้อย่างสร้างสรรค์และสมบูรณ์จากการใช้ระบบการคำแนะนำการใช้วัตถุดิบที่เป็นทางเลือก เนื่องจากอาหารไทยเป็นที่รู้จักอย่างแพร่หลายทั่วโลกและมีการเผยแพร่สูตรอาหารไทยพร้อมขั้นตอนการประกอบอาหารบนเว็บไซต์อาหาร ให้กับผู้ประกอบอาหารนำไปประกอบเอง แต่ในขณะเดียวกันการประกอบอาหารไทยอาจจะมีความยุ่งยากในด้านการจัดเตรียมวัตถุดิบให้เป็นไปตามสูตรอาหารสำหรับผู้เริ่มต้นประกอบอาหารทั้งชาวไทยและชาวต่างชาติ ด้วยเหตุผลนี้หากสามารถแนะนำวัตถุดิบอื่นที่สามารถใช้ทดแทนและเป็นทางเลือกให้กับผู้ประกอบอาหารนำไปใช้ได้ จะเป็นการช่วยผู้ประกอบอาหารมีทางเลือกในการใช้วัตถุดิบเพิ่มขึ้น อีกทั้งยังช่วยลดขั้นตอนและเวลาในการจัดเตรียมวัตถุดิบได้ ดังนั้นเพื่อส่งเสริมยุทธศาสตร์ชาติเกี่ยวกับเมืองนวัตกรรมอาหารในอนาคต หรือ "Food Innopolis" และส่งเสริมทางวิชาการข้ามศาสตร์ ในงานวิจัยครั้งนี้ใช้วิธีการ ออกแบบและพัฒนาต้นแบบระบบการหาวัตถุดิบที่เป็นทางเลือกหรือทดแทนในสูตรอาหารไทยด้วยเทคนิค smoothed correlation weight function และเทคนิค Strongly Connected Component (SCC) ความท้าทายในการ

วิจัยครั้งนี้คือความยากในด้านวิธีการจับคู่หาส่วนวัตถุดิบทดแทนหรือทางเลือก (alternative ingredient) ที่มีลักษณะคล้ายคลึงกับวัตถุดิบที่ต้องการแลกเปลี่ยน (exchange-ingredient) และเหมาะสมกับการนำไปใช้ประกอบอาหารในแต่ละสูตรอาหาร ในการพัฒนาอัลกอลิทึมของงานวิจัยและการทดสอบประสิทธิภาพของอัลกอลิทึมจะใช้ชุดข้อมูลอาหารออนไลน์ Yummly ซึ่งถูกรวบรวมและนำมาเผยแพร่สาธารณะในรูปแบบภาษาอังกฤษบนเว็บไซต์ www.lherranz.org /datasets/

2. ประโยชน์ต่อการปฏิบัติงานในตำแหน่งหน้าที่

1. ได้พัฒนาความเชี่ยวชาญของตนเอง และ สามารถนำผลงานที่พัฒนาตีพิมพ์เผยแพร่ครั้งนี้ยื่นขอกำหนดตำแหน่งทางวิชาการ
2. นำความรู้ที่ตนพัฒนาถ่ายทอดประสบการณ์การวิจัยสู่ชั้นเรียนในรายวิชา ทส 232, 323, 332
3. การสร้างผลงานและชื่อเสียงให้กับตนเอง
4. ได้รับแนวทางในการพัฒนาวิธีการจัดทำระบบการให้คำแนะนำในด้านการแนะนำวัตถุดิบที่เป็นทางเลือกในสูตรอาหารไทย

3. ประโยชน์ต่อหน่วยงาน (ระดับงาน/หลักสูตร/คณะ)

1. การสร้างผลงานวิชาการ ตีพิมพ์เผยแพร่ระดับนานาชาติให้กับทางหลักสูตร คณะ มหาวิทยาลัย และกระทรวงวิทยาศาสตร์และเทคโนโลยี
2. การเผยแพร่องค์ความรู้ที่ได้รับให้บุคลากรภายในองค์กรทราบ
3. ได้นวัตกรรมทางเทคโนโลยีใหม่ที่สามารถนำไปส่งเสริมการวิจัยนวัตกรรมอุตสหกรรมอาหารไทย
4. ได้ต้นแบบระบบการให้คำแนะนำวัตถุดิบที่เป็นทางเลือกหรือทดแทนให้กับสูตรอาหารไทยโดยกลุ่มวัตถุดิบที่แนะนำนั้นสามารถนำไปใช้แทนวัตถุดิบที่ต้องการแลกเปลี่ยนได้อย่างเหมาะสม และสามารถเพิ่มทางเลือกในการเลือกใช้วัตถุดิบในการประกอบอาหารไทยให้กับผู้ใช้

พร้อมนี้ได้แนบ ผลงานตีพิมพ์เผยแพร่เรื่อง Alternative-Ingredient Recommendation Based on Thai Recipe จากการเข้าประชุม/อบรมฯลฯ มาพร้อมนี้แล้ว จำนวน....1.....ชุด

จึงเรียนมาเพื่อโปรดทราบ

(.....)

นางสาววรรณวิมล นาดี

พนักงานมหาวิทยาลัย ตำแหน่ง อาจารย์

**ความคิดเห็นของผู้บังคับบัญชาชั้นต้น** (ประธานอาจารย์ผู้รับผิดชอบหลักสูตร/ผู้อำนวยการสำนักงาน/หัวหน้างาน)

บุคลากรดังกล่าวไปนำความรู้ไปใช้ประโยชน์ ดังนี้(โปรดระบุรายละเอียด)

.....เห็นควรให้เผยแพร่เพื่อเป็นประโยชน์ต่อบุคคลทั่วไป.....

.....

.....

(อาจารย์ ดร.สายัณห์ อุ่นนันกาศ)

(.....)

ประธานอาจารย์ผู้รับผิดชอบหลักสูตรวิทยาศาสตรบัณฑิต

...../...../.....

สาขาวิชาเทคโนโลยีการเกษตร

*หมายเหตุ : 1. เอกสารแนบเช่น สำเนาบทคัดย่อ หรือโปสเตอร์(ย่อขนาด A4) หรือบทความฯ ฉบับเต็มสำเนาใบรับรองหรือหนังสือรับรองหรือใบประกาศนียบัตรหรืออุปกรณ์ฯลฯ ซึ่งเป็นหลักฐานว่าได้เข้าร่วมงานจริง*

*2. กรณีที่ประสงค์จะรายงานฯ กรณีไม่ได้งบพัฒนาบุคลากรหรือไม่ใช้งบประมาณ ให้ใช้แบบฟอร์มฯ นี้*

*3. ให้จัดรูปแบบและขยายพื้นที่ตามรายละเอียดเนื้อหาหรือข้อความ ตามความเหมาะสม*


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# Welcome to ECTI DAMT & NCON 2021

**The 6th International Conference on Digital Arts, Media and Technology (DAMT) and 4th ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (NCON)**

On behalf of the ECTI DAMT & NCON, the organizing committee is delighted to invite you to the 6th International Conference on Digital Arts, Media and Technology (DAMT) and 4th ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (NCON), to be held as a hybrid conference, offering both onsite face-to-face sessions and online sessions, between 3rd to 6th March 2021 ECTI DAMT & NCON is the most comprehensive technical conference focused on the role of Information and Communication Technologies (ICT) organized by academics from 6 major universities in Northern Thailand: Chiang Mai University, Maejo University, Narasuan University, Mae Fah Luang University, Chiang Rai Rajabhat University, and University of Phayao. Moreover, Mahidol University, Thailand's top-ranked university, will be jointly held for this year. The ECTI DAMT & NCON 2021 conference will feature world-class presentations by internationally renowned speakers, cutting-edge session topics and provide a fantastic opportunity to network with like-minded professionals from around the world.

We are excited about the opportunity to innovate by creating an engaging our conference that will be rewarding for both presenters and attendees. Finally, we hope to provide an exceptional value for researchers, developers, designers, engineers and technologists.

**General Chair**
Pradorn Sureephong

## Welcome Message from the Technical Program Chair of ECTI DAMT and NCON 2021

Welcome, all guests of honor. On behalf of the Technical Program Committee, we are pleased to welcome you to the ECTI DAMT and NCON 2021. The conference technical program consisting of 4 online keynote sessions, 14 main tracks, and 3 special sessions.

We received a total of 110 paper submissions from 15 countries, out of which 89 papers have been accepted for the online presentation and published in the conference proceedings. Every paper went through a rigorous review process, in which each paper received at least three expert reviews. All papers that have been presented in the conference will be published in the IEEE Xplore Digital Library.

We would like to express our deepest gratitude to all committees and all authors for their great contributions to the ECTI DAMT and NCON 2021. We look forward to seeing everyone at our virtual conference and, also at the ECTI DAMT and NCON 2022 which will be held in Chiang Rai, Thailand next year. Thank you very much.

## Technical Program Chairs of the ECTI DAMT and NCON 2021

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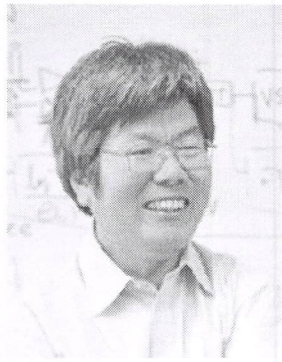
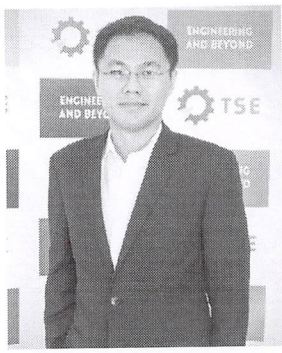
## KEYNOTE SPEAKERS



### Professor Minoru Okada

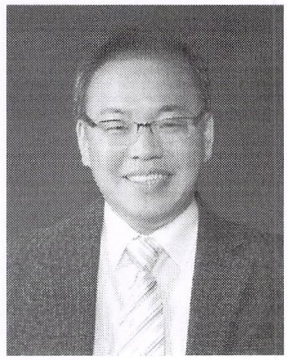
**Biography:** Minoru Okada received the B.E. degree in communications engineering from the University of Electro-Communications, Tokyo, Japan, in 1990. He received the M.E and Ph.D. degrees in communications engineering from Osaka University, Osaka, Japan, in 1992 and 1998, respectively. From 1993 to 2000, he was a Research Associate at Osaka University. From 1999 to 2000, he was a Visiting Research Fellow at University of Southampton, U.K. In 2000, he joined the Graduate School of Information Science, Nara Institute of Science and Technology, Nara, Japan, as an Associate Professor and became a Professor in 2006. His research interest is wireless communications, including WLAN, digital broadcasting, and satellite communications. Dr. Okada is a member of the Institute of Image, Information, and Television Engineers of Japan (ITEJ), the Institute of Television Engineers of Japan, the Institute of Electrical, Information, and Communication Engineers of Japan (IEICE), and the Information Processing Society of Japan (IPSJ). He received the Young Engineer Award from IEICE in 1999.




## Associate Professor Charturong Tantibundhit

**Biography:** Charturong Tantibundhit received the B.E. degree in electrical engineering from Kasetsart University, Bangkok, Thailand, in 1996. He received the M.S degree in information science and Ph.D. degree in electrical and computer engineering from the University of Pittsburgh, Pittsburgh, Pennsylvania USA, in 2001 and 2006, respectively. He has received many honors and awards from his research fields: deep learning, image processing, and speech processing. In 2006, he joined the Department of Electrical and Computer Engineering, Thammasat University, Pathumthani, Thailand, as an instructor and become an assistant professor and an associate professor in 2009 and 2013 respectively. Moreover, he is currently the head of Speech and Language Technology Cluster, Center of Excellence in Intelligent Informatics, Speech and Language Technology, and Service Innovation (CILS), Faculty of Engineering, Thammasat University, Pathumthani, Thailand.

**Abstract:** AIChest4All is the name of the model used to label and screening diseases in our area of focus, Thailand, including heart disease, lung cancer, and tuberculosis. This is aimed to aid radiologist in Thailand especially in rural areas, where there is immense staff shortages. Deep learning is used in our methodology to classify the chest X-ray images from datasets namely, NIH set, which is separated into 14 observations, and the Montgomery and Shenzhen set, which contains chest X-ray images of patients with tuberculosis, further supplemented by the dataset from Udonthani Cancer hospital and the National Chest Institute of Thailand. The images are classified into six categories: no finding, suspected active tuberculosis, suspected lung malignancy, abnormal heart and great vessels, Intrathoracic abnormal findings, and Extrathroacic abnormal findings. A total of 201,527 images were used. Results from testing showed that the accuracy values of the categories heart disease, lung cancer, and tuberculosis were 94.11%, 93.28%, and 92.32%, respectively with sensitivity values of 90.07%, 81.02%, and 82.33%, respectively and the specificity values were 94.65%, 94.04%, and 93.54%, respectively. In conclusion, the results acquired have sufficient accuracy, sensitivity, and specificity values to be used. Currently, AIChest4All is being used to help several of Thailand's government funded hospitals, free of charge.



# Professor Ilsun YOU

**Biography:** Dr. Ilsun YOU received the MS and PhD degrees in computer science from Dankook University, Seoul, Korea, in 1997 and 2002, respectively. He received the second PhD degree from Kyushu University, Japan, in 2012. From 1997 to 2004, he was at the THINmultimedia Inc., Internet Security Co., Ltd. and Hanjo Engineering Co., Ltd. as a research engineer. Now, he is a full professor at Department of Information Security Engineering, Soonchunhyang University. He has served or is currently serving as a General Chair or a Program Chair of international conferences and workshops such as WISA'19-20, MobiSec'16-19, AsiaARES'13-15, MIST'09-17, MobiWorld'08-17, and so forth. Dr. YOU is the EiC of Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications (JoWUA) and Journal of Internet Services and Information Security (JISIS). He is in the Editorial Board for Information Sciences (INS), Journal of Network and Computer Applications (JNCA), IEEE Access, International Journal of Ad Hoc and Ubiquitous Computing (IJAHUC), Computing and Informatics (CAI), and Journal of High Speed Networks (JHSN). Especially, he has focused on 4/5G security, security for wireless networks & mobile internet, IoT security and so forth while publishing more than 180 papers in these areas. He is a Fellow of the IET and a Senior member of the IEEE.

**Abstract:** 5G Security: The Beginning of Security for Next-Generation Telco-Applications

With the advent of the full-fledged 5G era, there is a growing expectation that 5G technology, which is characterized by ultra-fast, ultra-connected and ultra-low latency, will revolutionize our lives. Especially, 5G networks adopt edge cloud for application services within their area and provide network slicing based on network virtualization technologies to effectively support customized networks specialized for each application service. It is thus predicted that 5G will introduce innovative application services such as realistic contents, smart factories, autonomous vehicles, smart cities, and digital healthcare as well as lead the 4th industrial revolution.

In spite of such significant progress, 5G networks are followed by new and diverse security threats and attacks beyond our imagination, which cannot be addressed by traditional security technologies. Therefore, security is a necessary and sufficient condition for successful settlement of 5G networks. As the first step for 5G security, the 3GPP (3rd Generation Partnership Project) SA3, a working group responsible for security of telecommunication networks, has standardized 3GPP 5G security framework through its TS 33.501 document entitled "Security Architecture and

Procedures for 5G Systems". In this talk, 3GPP 5G security framework will be first outlined with its authentication, key management, and handover procedure, followed by the related works and research trends. Afterwards, focus will be on network slice security issues and secondary authentication, which is the key to opening the door for new security paradigm where each application is integrated with its best suit telecommunication and security service.

## Professor Samur Thanoi

**Biography:** Samur Thanoi received the B.E. degree in occupational therapy from Chiang Mai University, Chiang Mai, Thailand, in 1993. He received Ph.D. degree in anatomy and cell biology from the University of Sheffield, Sheffield, United Kingdom, in 2000. He has received many honours and awards from his research fields: anatomy & cell biology, reproduction biology, and assisted reproduction technology. In 1994, he joined the Department of Anatomy, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand, as an instructor and become an assistant professor and an associate professor in 2004 and 2008 respectively. Moreover, from 2018 to the present, he has joined the School of Medical Science, and has served as the Vice President for Research and Innovation, University of Phayao, Thailand. Finally, in 2020, he also becomes a professor of anatomy and cell biology for the research aspects of his academic career.

**Abstract:** Information and Communication Technology (ICT) has become very important in today life as it has been revealed that "the best brains of Europe come up with to improve health, wellbeing and ageing with the help of Information and Communication Technology (ICT)". There have been several research and innovation projects created in Europe in the following types: Projects that managing your health and care, Projects that innovate the health and care system and the way it works. ICT solutions supporting active and healthy ageing projects and Projects funded by the SME Instrument, accelerating market introduction of ICT solutions for Health, Well-being and Ageing Well. These all projects will help patients who suffering from the diseases can manage their life properly or try to live their lives independently, as well as to allow their doctors or their caregivers to get access to their personal data and apply the most suitable treatments or programs for each individual. Moreover, big data created or collected from the digital platform can also be benefit for other people or organizations in order to develop appropriate program for treatment of preventive programs. In Thailand these days, mobile applications have been created for monitoring and preventing the spreading of Covid-19. Thai Chana and MorChana have been launched for monitoring the spreading while Rao Chana is used for economic subsidies for the needy during the Covid-19 pandemic..

# Conference Programme

**Please note that the author should join the conference session before your presentation time** ***Video Conference via Zoom Webinar

**Mar 3th, 2021 (Wednesday)**

| | |
|---|---|
| 16.30 – 18.00 | **ECTI DAMT & NCON 2021 Steering Meeting**<br>**(ICT Meeting room, School of ICT, University of Phayao)** |
| 18.00 – 20.00 | **Welcome Party** |

**Mar 4th, 2021 (Thursday)**

| | | | | |
|---|---|---|---|---|
| 09.00 – 10.30 | **SS3: Innovative Applications of Artificial Intelligence**<br>**Room 1**<br>Session Chair: **Asst.Prof.Dr.Sakorn Mekruksavanich** | **SS3: Innovative Applications of Artificial Intelligence**<br>**Room 2**<br>Session Chair: **Dr.Narit Hnoohom** | **DAMT5: Digital Economy for Sustainable Growth**<br>**DAMT6: Knowledge Management and Learning Organization**<br>**SS2: Digital Business and Tourism Technology**<br>**Room 3**<br>Session Chair: **CMU** | **DAMT6: Knowledge Management and Learning Organization**<br>**Room 4**<br>Session Chair: **CMU** |
| | Paper ID: 69<br>Paper ID: 103<br>Paper ID: 104<br>Paper ID: 63<br>Paper ID: 67 | Paper ID: 82<br>Paper ID: 83<br>Paper ID: 84<br>Paper ID: 85<br>Paper ID: 81 | Paper ID: 29<br>Paper ID: 46<br>Paper ID: 50<br>Paper ID: 75<br>Paper ID: 80 | Paper ID: 35<br>Paper ID: 36<br>Paper ID: 37<br>Paper ID: 49<br>Paper ID: 54 |
| 10.30 – 10.45 | Coffee Break | | | |
| 10.45 – 12.00 | **SS3: Innovative Applications of Artificial Intelligence**<br>**Room 1**<br>Session Chair: **Dr.Narit Hnoohom** | **SS3: Innovative Applications of Artificial Intelligence**<br>**Room 2**<br>Session Chair: **Asst.Prof.Dr.Sakorn Mekruksavanich** | **DAMT6: Knowledge Management and Learning Organization**<br>**Room3**<br>Session Chair: **CMU** | **NCON3: Information Technology**<br>**Room 4**<br>Session Chair: **Asst.Prof.Dr Kreangsak Tamee** |
| | Paper ID: 43<br>Paper ID: 51<br>Paper ID: 73<br>Paper ID: 77<br>Paper ID: 65 | Paper ID: 44<br>Paper ID: 53<br>Paper ID: 107<br>Paper ID: 109<br>Paper ID: 68 | Paper ID: 8<br>Paper ID: 11<br>Paper ID: 21<br>Paper ID: 24<br>Paper ID: 22 | Paper ID: 16<br>Paper ID: 19<br>Paper ID: 25<br>Paper ID: 28<br>Paper ID: 38 |
| **ECTI DAMT & NCON 2021 Opening Ceremony (ROOM1)** | | | | |
| 14.15 – 14.30 | Coffee Break | | | |
| 14.30 – 15.15 | **Keynote Speech #1 Distinguish Speaker (ROOM1)**<br>• Professor Minoru Okada, Ph.D.<br>Nara Institute of Science and Technology, JAPAN | | | |
| 15.30 – 16.15 | **Keynote Speech #2 Distinguish Speaker (ROOM1)**<br>• Associate Professor Charturong Tantibundhit, Ph.D.<br>Thammasat University, THAILAND | | | |

# Conference Programme

| Mar 5th, 2021 (Friday) | | | | |
|---|---|---|---|---|
| 09.00 – 10.15 | **NCON1: Devices, Circuits and Systems**<br>**NCON4: Communication Systems**<br>**NCON7: Power Electronics**<br>**Room 1**<br>Session Chair: **Dr. Part Pramokchon** | **DAMT2: Multi-signal Processing and Applications**<br>**Room 2**<br>Session Chair: **Dr. Paween Khoenkaw** | **NCON2: Computers**<br>**Room3**<br>Session Chair: **Asst.Prof.Dr. Kreangsak Tamee** | **NCON2: Computers**<br>**NCON3: Information Technology**<br>**Room 4**<br>Session Chair: **Asst.Prof.Dr.Thana Udomsripaiboon** |
| | Paper ID: 5<br>Paper ID: 7<br>Paper ID: 20<br>Paper ID: 27 | Paper ID: 31<br>Paper ID: 56<br>Paper ID: 105 | Paper ID: 32<br>Paper ID: 39<br>Paper ID: 40<br>Paper ID: 41<br>Paper ID: 62 | Paper ID: 9<br>Paper ID: 42<br>Paper ID: 64<br>Paper ID: 74 |
| 10.15 – 10.30 | **Coffee Break** | | | |
| 10.30 – 11.15 | **Keynote Speech #3 Distinguish Speaker (ROOM1)**<br>• Professor Ilsun You, Ph.D.<br>Soonchunhyang University, KOREA | | | |
| 11.15 – 12.00 | **Keynote Speech #4 Distinguish Speaker (ROOM1)**<br>• Associate Professor Samur Thanoi, Ph.D.<br>University of Phayao, THAILAND | | | |
| 13.00 – 14.30 | **DAMT1: Media Systems and Implementations, Damt3: Digital Arts and Media**<br>**Room 1**<br>Session Chair: **CMU** | **SS3 CENTRAL**<br>**Room 2**<br>Session Chair: **MFU** | **SS3 CENTRAL**<br>**Room 3**<br>Session Chair: **MFU** | **SS3 CENTRAL**<br>**Room 4**<br>Session Chair: **MFU** |
| | Paper ID: 26<br>Paper ID: 30<br>Paper ID: 33<br>Paper ID: 57<br>Paper ID: 10<br>Paper ID: 76 | Paper ID: 52<br>Paper ID: 60<br>Paper ID: 61<br>Paper ID: 86<br>Paper ID: 87 | Paper ID: 95<br>Paper ID: 96<br>Paper ID: 97<br>Paper ID: 98<br>Paper ID: 100 | Paper ID: 93<br>Paper ID: 94<br>Paper ID: 110 |
| 14.30 – 14.45 | **Coffee Break** | | | |
| 14.45 – 16.00 | **NCON2: Computers**<br>**NCON3: Information Technology**<br>**Room 1**<br>Session Chair: **Dr.Sayan Unankard** | **SS3 CENTRAL**<br>**Room 2**<br>Session Chair: **MFU** | **SS3 CENTRAL**<br>**Room 3**<br>Session Chair: **MFU** | |
| | Paper ID: 6<br>Paper ID: 48<br>Paper ID: 55<br>Paper ID: 66 | Paper ID: 88<br>Paper ID: 89<br>Paper ID: 90<br>Paper ID: 91<br>Paper ID: 92 | Paper ID: 101<br>Paper ID: 102<br>Paper ID: 106<br>Paper ID: 108 | |

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The 6th International Conference on Digital Arts, Media and Technology (DAMT) and
4th ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (NCON)

# Alternative-Ingredient Recommendation Based on Correlation Weight for Thai Recipes

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***Abstract*—Cooking is a popular activity. Most people recently use recipes on the Website, which show the ingredients that are needed for a dish and the method of cooking. However, some of the listed ingredients sometimes are not able to prepare or use for cooking for some reasons: allergies, personal preference, or some ingredients are not available in the kitchen, etc. Therefore, it should recommend the alternative-ingredients that are similar to an exchange-ingredient and suitable with remained ingredients in the recipe. This paper proposes a recommendation system of alternative ingredients for Thai recipes. The recommended method is based on the combination of the smoothed correlation weight function and graph-based approach on the Thai recipe database. Our research contributes to enhancing the cooking beginners to cook Thai food and prepare ingredients conveniently by using the alternative-ingredients.**

***Keywords*—Alternative ingredient recommendation, Food innovation, Text mining, Data mining, Recommendation system, Thai recipes.**

## I. Introduction

The recipe websites are a popular source of sharing recipes and cooking methods from different cuisines. They open a new door for people who are looking for their favorite dishes and want to try a new dish that they would never try. As the recipe websites make recipes easier to access, thereby people turn to recipe websites where they can share and find information easily. A recipe on the Website shows the ingredients that are needed for a dish and the cooking process. However, sometimes people want to cook an unfamiliar dish and they could not get all the ingredients listed on the recipe [1]. In other words, some of the listed ingredients sometimes are not able to prepare or use for cooking for some reasons: allergies, religions of individuals living, personal preference, some ingredients are not available in the kitchen or specific ingredients are not able to source the right ones at the moment [2]. To address these problems, we want to discover a suitable alternative-ingredient that goes well with the remained ingredients in that recipe for substitution.

Search and recommendation systems play an important role in the way people choose what they eat [3]. There has been much research on recipe recommendation systems that were developed for different purposes. Most existing works mainly focus on the analysis of recipes based on recipe content (e.g., ingredient). For example, Sajadmanesh et al. [4] used the ingredients, taste, and cuisine information to understand culinary habit around the world. Elsweiler et al. [3] exploited the online recipe to help people to choose a healthier meal. They investigated users' behavior of how people perceive and select recipes. The machine learning techniques are applied to find the replacement recipes and predict the preferred recipes. Moreover, Shino et al. [2] and Yamanish et al. [5] conducted the alternative ingredients recommendation systems based on co-occurrence relation among ingredient category information. The basic idea of choosing alternative ingredients is based on the similarity and compatibility of ingredients in the same category. They mentioned the ingredients belonging to the same category of the exchanged-ingredient were more suitable as alternative-ingredient. Whereas Lui et al. [1] used the ingredients co-occurrence frequency along with category importance calculated from recipe data for each replacement. Their method can recommend suitable ingredients with a diversity of ingredients.

This paper proposes a recommendation system of alternative ingredients for Thai recipes. Thai cuisine is one of the world's great cuisines and is also a unique food. Cooking Thai food might not be easy for beginners regarding preparing the ingredients listed in the recipe. Due to they do not have a specific or main ingredient listed in the refrigerator. Thus, we need to find another ingredient that is suitable with the remained ingredients and in the same category in that recipe for replacement. For instance, we want to make Thai green curry but we cannot find the chicken in our kitchen. We might desire to use something other to replace chicken such as pork or beef or meat or seafood. The goal of this study is to enhance the cooking beginners to cook Thai food and prepare ingredients conveniently by using the alternative-ingredients. Our basic idea is to exploit the concept of co-occurrence of ingredients along with the smoothed correlation weight function to calculate the important weight give to each ingredient on recipe data. Then we leverage the strong relations among exchange-ingredients and other ingredients using the graph-based approach to capture the alternative-ingredients. The challenge of this work is how to discover the alternative ingredients that are similar and proper to an exchange-ingredient in the complex relationships between

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ingredients.

The main contributions of this work are an approach based on the combination of three techniques that can find appropriate ingredients when recommending alternative ingredients. Furthermore, we use what we learn to establish the preliminary model of alternative ingredient recommendation for Thai recipes which considers only the main ingredient. The evaluation of our method based on the Thai recipe dataset collected from the Yummly website. The experimental results were compared with these two methods which demonstrate the proposed approach can improve the effectiveness of recommendations.

The rest of this paper as follows: Section 2 discusses related work in recipe recommendation systems and the alternative ingredient recommendation systems; Section 3 presents the proposed alternative ingredient recommendation method; Section 4 describes our experiments and analysis; Section 5 summarizes our findings and suggests possible future work.

## II. Related Works

The study of food recommendation systems has been increasing due to their relevance for healthy living. The recipe content on the Web provides valuable information to the food research community. The studies on recipe mainly focus on recipe recommendation, menu recommendation, and ingredient replacement [1]. For example, food pairing focuses on a similar flavor of ingredients; if a flavor of an ingredient is similar to another one. The ingredients are suggested to be used together. The food pairing hypothesis has been studied for several modern cuisines. Earlier studies of food pairing are Ahn et al. [6] and Varshney et al. [7] examined a flavor network involving ingredients derived from recipe to capture their flavor bonds. Mao et al. [8] and GUO et al.[9] utilized the flavor pairing concept to recommend a set of dishes from the various Chinese regional cuisines for a certain flavor preference in terms of flavor similarity. The cosine similarity and the TF-IDF algorithm are applied to choose the dishes with the most similar flavors and recommend them to the users. Our work is related to an alternative ingredient recommendation system, which is used to recommend an alternative if a particular ingredient is not present or cannot be used in the recipe [10]. Previous works are proposed in [1], [2], [5], [11], the authors conducted the approaches based on co-occurrence relation among ingredient category information. The basic idea of choosing alternative ingredients is based on the similarity and compatibility of ingredients in the same category. They mentioned the ingredients belonging to the same category of the exchanged-ingredient were more suitable as alternative-ingredient. They define such an ingredient that cannot be used in the cooking as "exchange-ingredient". Their method only recommending the ingredient in the same category, the suitable ingredients in different categories are not taken to consideration. While Lui et al. [1] mentioned that their algorithm ignores suitable ingredients in different categories. Then, they utilized the ingredients co-occurrence frequency along with category importance calculated from recipe data for each replacement. Their method provides suitable ingredients with a diversity of ingredients. Maheshwari and Chourey [10] proposed a machine learning model to innovate new dishes and to help people allergic to certain ingredients by recommending alternate ingredients. It has shown that the ingredient co-occurrence frequency is widely used in the alternative-ingredient recommendations. However, our work relies on smoothed correlation weight function to calculate the important weight based on the relation among ingredients in the recipe. A graph-based approach is utilized to discover the relation between the exchange-ingredient and the replace ingredients.

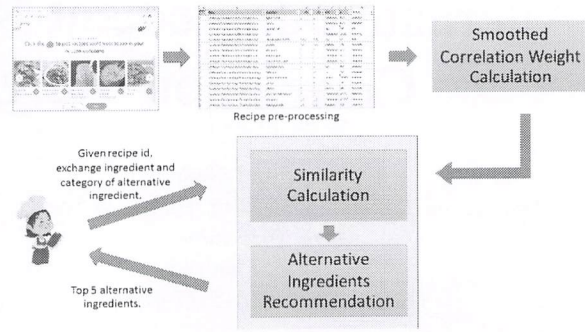


Fig. 1. The architecture of our system.

## III. Proposed Method

In this task, we present our approach to recommending alternative ingredient for Thai recipes. Figure 1 shows a conceptual framework of our approach. It can be divided into three steps: Recipe pre-processing, Smoothed correlation weight calculation, Similarity calculation and Alternative ingredients recommendation. The details of each step of our approach are given in the following.

### A. Recipe Pre-processing

In order to improve the quality of our dataset and the performance of the proposed approach, the pre-processing is performed. Thai recipes are extracted from the dataset. We manually assigned each ingredient to a category and renamed the ingredient to the proper one such as "boneless beef steak", "beef steak" and "beefsteak" to "beef steak". Example of the dataset after pre-processing is shown in Table I.

TABLE I
Example of the dataset after pre-processing.

| Recipe Name | Ingredient | Quantity | Unit | Category |
|---|---|---|---|---|
| Tom Kha Gai | chicken | 1 | pound | meat |
| Tom Kha Gai | coconut milk | 2 | can | milk |
| Tom Kha Gai | coconut oil | 3 | tablespoon | oil |
| Tom Kha Gai | fish sauce | 1 | tablespoon | seasoning |
| Tom Kha Gai | galangal | 2 | tablespoon | vegetable |
| ... | ... | .. | ... | ... |

### B. Smoothed correlation weight calculation

In this task, we aim to find the relationship between two ingredients. Our intuition is that ingredients frequently co-occur when they have meaningful relationships between them. To extract the set of co-occurring ingredients, the directed edge-weighted graph is created. The edge is created if the correlation weight score between two ingredients greater than zero. Example of the directed edge-weighted graph is show in Figure 2. We adopt the smoothed correlation weight function to calculate the semantic correlation weight between two ingredients. All ingredients are used to calculate the correlation weight between two ingredients because some ingredients can sometimes be both seasoning and primary ingredients in different recipes. The formula is shown below:

$$A = (n_{xy} + \frac{n_x}{N})/(n_x - n_{xy} + 1) \quad (1)$$

$$B = (n_x - n_{xy} + \frac{n_x}{N})/(N - n_x - n_y + n_{xy} + 1) \quad (2)$$

$$SCW_{x,y} = log(\frac{A}{B}) \quad (3)$$

where $SCW_{x,y}$ is a correlation weight score between ingredient $x$ and y, $n_x$ is a number of recipes containing ingredient $x$, $n_y$ is a number of recipes containing ingredient $y$, $n_{xy}$ is a number of recipes containing both ingredient $x$ and $y$, while $N$ is the total number of recipes.

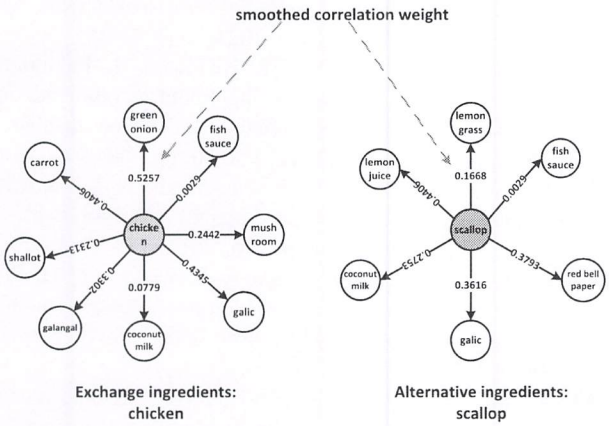


Fig. 2. Example of the directed edge-weighted graph.

### C. Similarity calculation and Alternative ingredients recommendation

The problem that we address in this section is how to find the similarity of ingredients for the alternative recommendation. For a given category, a direct edge-weight graph of each ingredient in a given category is created. Each graph of candidate ingredient will be compared with the exchange ingredient graph. The cosine similarity between the two graphs will be used to find the similarity between the exchange ingredients and candidate alternative ingredients. The top 5 ingredients with the highest similarity scores will be recommended to the user. The cosine similarity function is shown below:

$$iSim(ex, al) = \frac{\sum_i (SCW_{ex_i} \times SCW_{al_i})}{\sqrt{\sum_j SCW_{ex_j}^2} \times \sqrt{\sum_k SCW_{al_k}^2}} \quad (4)$$

where $iSim(ex, al)$ is a similarity value between ingredient $ex$ and $al$ while $ex$ and $al$ are directed edge-weighted graphs of exchange ingredient and alternative ingredient respectively.

## IV. Experiments and Evaluation

### A. Dataset

The Yummly-28K recipe dataset collected from Yummly and provided by www.lherranz.otg/datasets/ to develop our algorithms and evaluate the performance. We collected only Thai recipes which consist of 832 dishes and 868 ingredients.

### B. Baseline

In order to evaluate our approach, we compare our approach performance with the co-occurrence frequency approach adopted from [2]. We calculated the occurrence frequency of an ingredient and the co-occurrence frequency of two ingredients. For solving an orthographical variant with a cooking ontology, we cannot perform this step because we do not have a cooking ontology. Then, the compatibility score between the ingredient and the recipe is calculated. The top 5 alternative ingredients with the highest scores of the proportion of alternative ingredients with compatibility score of all ingredients in a recipe database will be recommended.

### C. Evaluation

In this section, we evaluate the performance of our approach. The experiments were conducted with four recipes. The four recipes of our evaluation are shown in Table II. The top 5 ingredients for a selected category are recommended. The example of the top 5 recommended ingredients is shown in Table III. For preliminary evaluation, we asked 7 participants who have Thai cooking experience from 6 countries (Thailand, Australia, Korea, Norway, Germany, and the other two from the USA) to evaluate whether the recommended ingredients were suitable as an alternative or not based on their experience on cooking. The participant will give a score (1-5) for each recommended ingredient. More point means the ingredient is more suitable for the replacement. The result of our evaluation is shown in Table IV. However, for the taste evaluation, we will conduct it in our future work.

TABLE II
THE FOUR RECIPES OF OUR EVALUATION.

| Menu Name | Exchange ingredient | Alternative Category |
|---|---|---|
| Tom Kha Gai | chicken | meat, seafood |
| Thai Green Curry | coconut milk | milk, nuts |
| Thai Basil Beef | beef | meat, seafood |
| Thai Papaya Salad | green papaya | meat, seafood, vegetable, fruit |

In Table IV, our approach achieves a higher average score over the baseline. The results show that most participants

TABLE III
THE EXAMPLE OF TOP 5 RECOMMENDED INGREDIENTS TO REPLACE "GREEN PAPAYA" FOR THAI PAPAYA SALAD.

| | Vegetable | Fruit | Meat | Seafood |
|---|---|---|---|---|
| Baseline | ginger (9)<br>lemongrass (11)<br>red bell pepper (11)<br>green onion (10)<br>shallot (11) | mango (29)<br>pineapple (17)<br>coconut (11)<br>coconut flakes (8)<br>avocado (15) | chicken breast (18)<br>chicken (16)<br>chicken thighs (16)<br>sirloin steak (18)<br>boneless chicken thighs (17) | shrimp (20)<br>red snapper (13)<br>salmon fillet (19)<br>prawns (18)<br>whitefish fillets (13) |
| Our approach | green long beans (31)<br>salad (24)<br>green cabbage (26)<br>shallot (11)<br>cucumber (33) | mango (28)<br>avocado (15)<br>coconut (11)<br>pomegranate seeds (10)<br>pineapple (17) | chicken thighs (17)<br>pork (17)<br>ground pork (16)<br>sirloin steak (18)<br>boneless pork lion roast (15) | shrimp (19)<br>salmon fillet (18)<br>whitefish fillets (13)<br>halibut fillets (13)<br>prawns (18) |

(x) is a total score from 7 participants given for each recommended ingredient.

TABLE IV
THE AVERAGE SUITABLE SCORE (1 - 5) OF OUR EVALUATION.

| Participant | Country | Baseline | Our Approach |
|---|---|---|---|
| 1 | Thailand | 2.52 | **2.84** |
| 2 | Australia | 3.30 | **3.56** |
| 3 | Korea | 3.08 | **3.40** |
| 4 | Norway | 2.66 | **2.70** |
| 5 | USA | 2.78 | **2.98** |
| 6 | USA | **2.46** | 2.20 |
| 7 | Germany | 2.46 | **2.64** |
| | **Average** | **2.75** | **2.90** |

prefer our recommended results except one participant from the USA. In addition, participants from Australia and Korea gave average scores greater than 3.00 while participants from the USA and Germany gave average scores less than 2.50. This may be due to the variety of ingredients in each country and individual preferences.

## V. CONCLUSIONS

In this paper, an alternative-ingredient recommendation system for Thai recipes is proposed. The goal of this study is to effectively recommend alternative ingredients to replace a specific ingredient in a recipe. Our contributions are summarized as follows: (1) we introduced a recommendation approach of alternative ingredients for Thai recipes and (2) the incorporation between smoothed correlation weight and graph-based approach achieved better results than the baseline. In future work, we will further consider the quantity of each ingredient in the recipe. Cooking demonstration and taste evaluation will be conducted.

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# Alternative-Ingredient Recommendation Based on Correlation Weight for Thai Recipes

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***Abstract*—Cooking is a popular activity. Most people recently use recipes on the Website, which show the ingredients that are needed for a dish and the method of cooking. However, some of the listed ingredients sometimes are not able to prepare or use for cooking for some reasons: allergies, personal preference, or some ingredients are not available in the kitchen, etc. Therefore, it should recommend the alternative-ingredients that are similar to an exchange-ingredient and suitable with remained ingredients in the recipe. This paper proposes a recommendation system of alternative ingredients for Thai recipes. The recommended method is based on the combination of the smoothed correlation weight function and graph-based approach on the Thai recipe database. Our research contributes to enhancing the cooking beginners to cook Thai food and prepare ingredients conveniently by using the alternative-ingredients.**

***Keywords*—Alternative ingredient recommendation, Food innovation, Text mining, Data mining, Recommendation system, Thai recipes.**

## I. Introduction

The recipe websites are a popular source of sharing recipes and cooking methods from different cuisines. They open a new door for people who are looking for their favorite dishes and want to try a new dish that they would never try. As the recipe websites make recipes easier to access, thereby people turn to recipe websites where they can share and find information easily. A recipe on the Website shows the ingredients that are needed for a dish and the cooking process. However, sometimes people want to cook an unfamiliar dish and they could not get all the ingredients listed on the recipe [1]. In other words, some of the listed ingredients sometimes are not able to prepare or use for cooking for some reasons: allergies, religions of individuals living, personal preference, some ingredients are not available in the kitchen or specific ingredients are not able to source the right ones at the moment [2]. To address these problems, we want to discover a suitable alternative-ingredient that goes well with the remained ingredients in that recipe for substitution.

Search and recommendation systems play an important role in the way people choose what they eat [3]. There has been much research on recipe recommendation systems that were developed for different purposes. Most existing works mainly focus on the analysis of recipes based on recipe content (e.g., ingredient). For example, Sajadmanesh et al. [4] used the ingredients, taste, and cuisine information to understand culinary habit around the world. Elsweiler et al. [3] exploited the online recipe to help people to choose a healthier meal. They investigated users' behavior of how people perceive and select recipes. The machine learning techniques are applied to find the replacement recipes and predict the preferred recipes. Moreover, Shino et al. [2] and Yamanish et al. [5] conducted the alternative ingredients recommendation systems based on co-occurrence relation among ingredient category information. The basic idea of choosing alternative ingredients is based on the similarity and compatibility of ingredients in the same category. They mentioned the ingredients belonging to the same category of the exchanged-ingredient were more suitable as alternative-ingredient. Whereas Lui et al. [1] used the ingredients co-occurrence frequency along with category importance calculated from recipe data for each replacement. Their method can recommend suitable ingredients with a diversity of ingredients.

This paper proposes a recommendation system of alternative ingredients for Thai recipes. Thai cuisine is one of the world's great cuisines and is also a unique food. Cooking Thai food might not be easy for beginners regarding preparing the ingredients listed in the recipe. Due to they do not have a specific or main ingredient listed in the refrigerator. Thus, we need to find another ingredient that is suitable with the remained ingredients and in the same category in that recipe for replacement. For instance, we want to make Thai green curry but we cannot find the chicken in our kitchen. We might desire to use something other to replace chicken such as pork or beef or meat or seafood. The goal of this study is to enhance the cooking beginners to cook Thai food and prepare ingredients conveniently by using the alternative-ingredients. Our basic idea is to exploit the concept of co-occurrence of ingredients along with the smoothed correlation weight function to calculate the important weight give to each ingredient on recipe data. Then we leverage the strong relations among exchange-ingredients and other ingredients using the graph-based approach to capture the alternative-ingredients. The challenge of this work is how to discover the alternative ingredients that are similar and proper to an exchange-ingredient in the complex relationships between

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ingredients.

The main contributions of this work are an approach based on the combination of three techniques that can find appropriate ingredients when recommending alternative ingredients. Furthermore, we use what we learn to establish the preliminary model of alternative ingredient recommendation for Thai recipes which considers only the main ingredient. The evaluation of our method based on the Thai recipe dataset collected from the Yummly website. The experimental results were compared with these two methods which demonstrate the proposed approach can improve the effectiveness of recommendations.

The rest of this paper as follows: Section 2 discusses related work in recipe recommendation systems and the alternative ingredient recommendation systems; Section 3 presents the proposed alternative ingredient recommendation method; Section 4 describes our experiments and analysis; Section 5 summarizes our findings and suggests possible future work.

## II. Related Works

The study of food recommendation systems has been increasing due to their relevance for healthy living. The recipe content on the Web provides valuable information to the food research community. The studies on recipe mainly focus on recipe recommendation, menu recommendation, and ingredient replacement [1]. For example, food pairing focuses on a similar flavor of ingredients; if a flavor of an ingredient is similar to another one. The ingredients are suggested to be used together. The food pairing hypothesis has been studied for several modern cuisines. Earlier studies of food pairing are Ahn et al. [6] and Varshney et al. [7] examined a flavor network involving ingredients derived from recipe to capture their flavor bonds. Mao et al. [8] and GUO et al.[9] utilized the flavor pairing concept to recommend a set of dishes from the various Chinese regional cuisines for a certain flavor preference in terms of flavor similarity. The cosine similarity and the TF-IDF algorithm are applied to choose the dishes with the most similar flavors and recommend them to the users. Our work is related to an alternative ingredient recommendation system, which is used to recommend an alternative if a particular ingredient is not present or cannot be used in the recipe [10]. Previous works are proposed in [1], [2], [5], [11], the authors conducted the approaches based on co-occurrence relation among ingredient category information. The basic idea of choosing alternative ingredients is based on the similarity and compatibility of ingredients in the same category. They mentioned the ingredients belonging to the same category of the exchanged-ingredient were more suitable as alternative-ingredient. They define such an ingredient that cannot be used in the cooking as "exchange-ingredient". Their method only recommending the ingredient in the same category, the suitable ingredients in different categories are not taken to consideration. While Lui et al. [1] mentioned that their algorithm ignores suitable ingredients in different categories. Then, they utilized the ingredients co-occurrence frequency along with category importance calculated from recipe data for each replacement. Their method provides suitable ingredients with a diversity of ingredients. Maheshwari and Chourey [10] proposed a machine learning model to innovate new dishes and to help people allergic to certain ingredients by recommending alternate ingredients. It has shown that the ingredient co-occurrence frequency is widely used in the alternative-ingredient recommendations. However, our work relies on smoothed correlation weight function to calculate the important weight based on the relation among ingredients in the recipe. A graph-based approach is utilized to discover the relation between the exchange-ingredient and the replace ingredients.

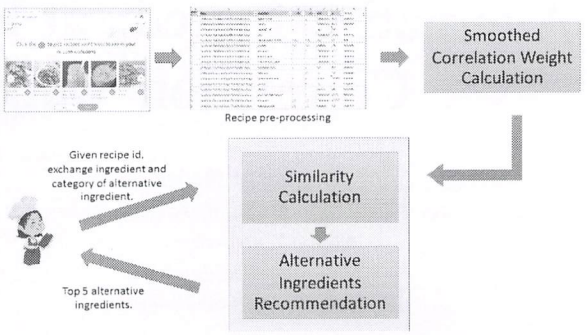


Fig. 1. The architecture of our system.

## III. Proposed Method

In this task, we present our approach to recommending alternative ingredient for Thai recipes. Figure 1 shows a conceptual framework of our approach. It can be divided into three steps: Recipe pre-processing, Smoothed correlation weight calculation, Similarity calculation and Alternative ingredients recommendation. The details of each step of our approach are given in the following.

### A. Recipe Pre-processing

In order to improve the quality of our dataset and the performance of the proposed approach, the pre-processing is performed. Thai recipes are extracted from the dataset. We manually assigned each ingredient to a category and renamed the ingredient to the proper one such as "boneless beef steak", "beef steak" and "beefsteak" to "beef steak". Example of the dataset after pre-processing is shown in Table I.

TABLE I
Example of the dataset after pre-processing.

| Recipe Name | Ingredient | Quantity | Unit | Category |
|---|---|---|---|---|
| Tom Kha Gai | chicken | 1 | pound | meat |
| Tom Kha Gai | coconut milk | 2 | can | milk |
| Tom Kha Gai | coconut oil | 3 | tablespoon | oil |
| Tom Kha Gai | fish sauce | 1 | tablespoon | seasoning |
| Tom Kha Gai | galangal | 2 | tablespoon | vegetable |
| ... | ... | .. | ... | ... |

### B. Smoothed correlation weight calculation

In this task, we aim to find the relationship between two ingredients. Our intuition is that ingredients frequently co-occur when they have meaningful relationships between them. To extract the set of co-occurring ingredients, the directed edge-weighted graph is created. The edge is created if the correlation weight score between two ingredients greater than zero. Example of the directed edge-weighted graph is show in Figure 2. We adopt the smoothed correlation weight function to calculate the semantic correlation weight between two ingredients. All ingredients are used to calculate the correlation weight between two ingredients because some ingredients can sometimes be both seasoning and primary ingredients in different recipes. The formula is shown below:

$$A = (n_{xy} + \frac{n_x}{N})/(n_x - n_{xy} + 1) \quad (1)$$

$$B = (n_x - n_{xy} + \frac{n_x}{N})/(N - n_x - n_y + n_{xy} + 1) \quad (2)$$

$$SCW_{x,y} = log(\frac{A}{B}) \quad (3)$$

where $SCW_{x,y}$ is a correlation weight score between ingredient $x$ and y, $n_x$ is a number of recipes containing ingredient $x$, $n_y$ is a number of recipes containing ingredient $y$, $n_{xy}$ is a number of recipes containing both ingredient $x$ and $y$, while $N$ is the total number of recipes.

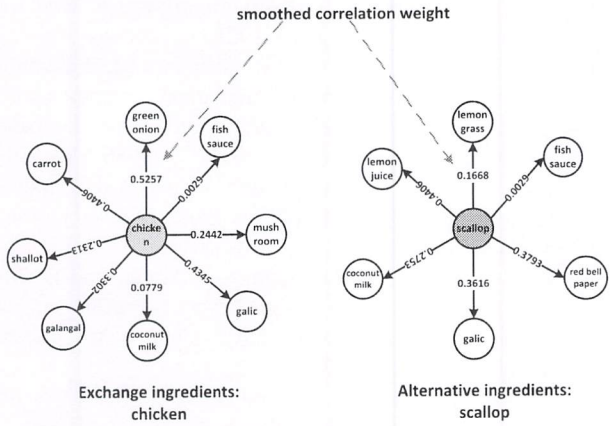


Fig. 2. Example of the directed edge-weighted graph.

### C. Similarity calculation and Alternative ingredients recommendation

The problem that we address in this section is how to find the similarity of ingredients for the alternative recommendation. For a given category, a direct edge-weight graph of each ingredient in a given category is created. Each graph of candidate ingredient will be compared with the exchange ingredient graph. The cosine similarity between the two graphs will be used to find the similarity between the exchange ingredients and candidate alternative ingredients. The top 5 ingredients with the highest similarity scores will be recommended to the user. The cosine similarity function is shown below:

$$iSim(ex, al) = \frac{\sum_i (SCW_{ex_i} \times SCW_{al_i})}{\sqrt{\sum_j SCW_{ex_j}^2} \times \sqrt{\sum_k SCW_{al_k}^2}} \quad (4)$$

where $iSim(ex, al)$ is a similarity value between ingredient $ex$ and $al$ while $ex$ and $al$ are directed edge-weighted graphs of exchange ingredient and alternative ingredient respectively.

## IV. Experiments and Evaluation

### A. Dataset

The Yummly-28K recipe dataset collected from Yummly and provided by www.lherranz.otg/datasets/ to develop our algorithms and evaluate the performance. We collected only Thai recipes which consist of 832 dishes and 868 ingredients.

### B. Baseline

In order to evaluate our approach, we compare our approach performance with the co-occurrence frequency approach adopted from [2]. We calculated the occurrence frequency of an ingredient and the co-occurrence frequency of two ingredients. For solving an orthographical variant with a cooking ontology, we cannot perform this step because we do not have a cooking ontology. Then, the compatibility score between the ingredient and the recipe is calculated. The top 5 alternative ingredients with the highest scores of the proportion of alternative ingredients with compatibility score of all ingredients in a recipe database will be recommended.

### C. Evaluation

In this section, we evaluate the performance of our approach. The experiments were conducted with four recipes. The four recipes of our evaluation are shown in Table II. The top 5 ingredients for a selected category are recommended. The example of the top 5 recommended ingredients is shown in Table III. For preliminary evaluation, we asked 7 participants who have Thai cooking experience from 6 countries (Thailand, Australia, Korea, Norway, Germany, and the other two from the USA) to evaluate whether the recommended ingredients were suitable as an alternative or not based on their experience on cooking. The participant will give a score (1-5) for each recommended ingredient. More point means the ingredient is more suitable for the replacement. The result of our evaluation is shown in Table IV. However, for the taste evaluation, we will conduct it in our future work.

TABLE II
THE FOUR RECIPES OF OUR EVALUATION.

| Menu Name | Exchange ingredient | Alternative Category |
|---|---|---|
| Tom Kha Gai | chicken | meat, seafood |
| Thai Green Curry | coconut milk | milk, nuts |
| Thai Basil Beef | beef | meat, seafood |
| Thai Papaya Salad | green papaya | meat, seafood, vegetable, fruit |

In Table IV, our approach achieves a higher average score over the baseline. The results show that most participants

TABLE III
THE EXAMPLE OF TOP 5 RECOMMENDED INGREDIENTS TO REPLACE "GREEN PAPAYA" FOR THAI PAPAYA SALAD.

| | Vegetable | Fruit | Meat | Seafood |
|---|---|---|---|---|
| Baseline | ginger (9)<br>lemongrass (11)<br>red bell pepper (11)<br>green onion (10)<br>shallot (11) | mango (29)<br>pineapple (17)<br>coconut (11)<br>coconut flakes (8)<br>avocado (15) | chicken breast (18)<br>chicken (16)<br>chicken thighs (16)<br>sirloin steak (18)<br>boneless chicken thighs (17) | shrimp (20)<br>red snapper (13)<br>salmon fillet (19)<br>prawns (18)<br>whitefish fillets (13) |
| Our approach | green long beans (31)<br>salad (24)<br>green cabbage (26)<br>shallot (11)<br>cucumber (33) | mango (28)<br>avocado (15)<br>coconut (11)<br>pomegranate seeds (10)<br>pineapple (17) | chicken thighs (17)<br>pork (17)<br>ground pork (16)<br>sirloin steak (18)<br>boneless pork lion roast (15) | shrimp (19)<br>salmon fillet (18)<br>whitefish fillets (13)<br>halibut fillets (13)<br>prawns (18) |

(x) is a total score from 7 participants given for each recommended ingredient.

TABLE IV
THE AVERAGE SUITABLE SCORE (1 - 5) OF OUR EVALUATION.

| Participant | Country | Baseline | Our Approach |
|---|---|---|---|
| 1 | Thailand | 2.52 | **2.84** |
| 2 | Australia | 3.30 | **3.56** |
| 3 | Korea | 3.08 | **3.40** |
| 4 | Norway | 2.66 | **2.70** |
| 5 | USA | 2.78 | **2.98** |
| 6 | USA | **2.46** | 2.20 |
| 7 | Germany | 2.46 | **2.64** |
| | **Average** | **2.75** | **2.90** |

prefer our recommended results except one participant from the USA. In addition, participants from Australia and Korea gave average scores greater than 3.00 while participants from the USA and Germany gave average scores less than 2.50. This may be due to the variety of ingredients in each country and individual preferences.

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