Reusable, Sharable, and Transferable Smart Data Platform for Collaborative Development of Data-Driven Smart Cities (year 2)

Background :

- UN's Sustainable Development Goals (https://sdgs.un.org/goals)
  - Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
  - Goal 13: Take urgent action to combat climate change and its impacts
  - Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development
- Society 5.0 (https://www8.cao.go.jp/cstp/english/society5_0/index.html)
  - "A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space."

Targets:

- Disaster risk reduction and sustainable transport
  - Smart environmental Tourism and Sustainable Mobility (Dalat city, Vietnam)
  - Smart Dengue Early Warning System (Cauayan City, Philippines)
  - Smart Outdoor Activities (Singapore)
- Atmosphere and Climate Change
  - Transboundary Air-Pollution Forecasting (Brunei)
- Multi-stakeholder partnerships and voluntary commitments
  - xData Platform and Event Data Sharing: A decentralized and collaborative approach to fast, economically, and sustainably develop user-centered applications.

Speaker: Minh-Son Dao

Reusable, Sharable, and Transferable Smart Data Platform for Collaborative Development of Data-Driven Smart Cities

Project Members :

- **Minh-Son Dao,** National Institute of Information and Communications Technology, Japan (NICT
- **Asem Kasem,** Universiti Teknologi Brunei (UTB)
- **Dang Thanh Hai,** Dalat University, Vietnam (DLU)
- **Filip Biljecki,** National University of Singapore (NUS)
- **Betchie Aguinaldo,** Isabele State University in Cauayan, the Philippines (ISU)

Project Duration :

- 24 months (2019/04/01 – 2022/03/31)

Project Budget:

- 40,000 USD/year

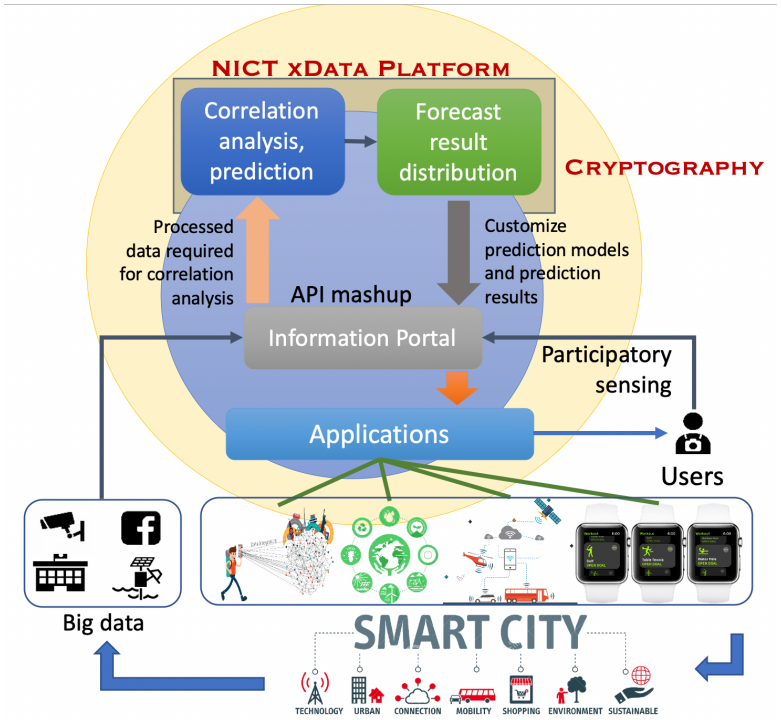
Project Activities: Scientific and Technological Development

1. Scientific

- Values and Complex Events Prediction
- Insights from cross-data
- Decentralized and collaborative development
- Data Visualization and Geo-based Navigation

2. Technological development

- Deep Multimodal Learning for Predicting Haze Transboundary using peripheral and weather from stations and open data.
- Discovering Periodic-Frequent Patterns in Very Large Uncertain Temporal Databases.



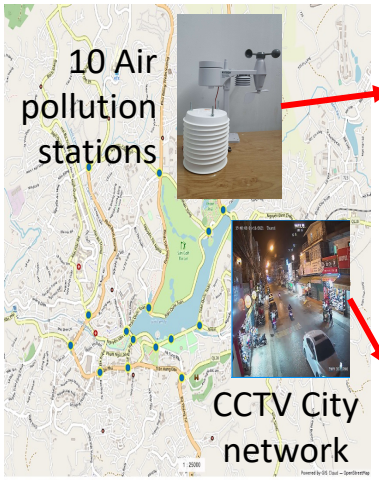
- Cross-Data model, Fuzzy membership and Visual pollution Integrating for Air pollution Estimation and Prediction using Images.
- Interactive Incident Retrieval System for First-view Travel-log Data with new incident classes automatically generation engine.
- Graph-based CCTV network dataset and baseline methods for Traffic Flow.
- Data collection system (e.g., sensor networks, crowdsourcing).
- A risk-avoidable navigation system based on cross-data.

Project Activities: Experiments including field testing

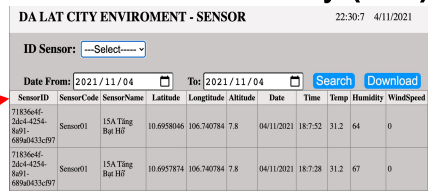
- Sensor Networks designation and deployment
  - Environment-mobility sensor networks in Dalat city (Vietnam)
  - Dengue sensor networks in Cauayan city (Philippines)
- Data structure and database designation based on 3D-GIS data format to harmonize data exchanged among partners and to further adapt to smart cities (Singapore)
- Data collection:
  - Collect haze trans-border-related datasets (air pollution, fire forest, weather) from ASEAN countries (UTB)
  - Collect Dengue-related dataset in Cauayan city, the Philippines (ISU)
  - Collect CCTV videos and environment-weather dataset in Dalat city, Vietnam (DLU)
  - Collect first-view travel-log data for 8 typical road incidents from open sources (NICT)
- Transfer knowledge:
  - Transfer models and tools developed by NICT to partners for reusing on local data.
- Models Evaluation:
  - Evaluate the adaptability and accuracy of transferred models on local data (UTB, NICT, DLU, NUS)
- System Manual Instruction:
  - Construct the website to give manual instructions for reusing and sharing products developed by partners (https://www.xdata.nict.jp/xDataPFDocs/WebAPI/1.0/en/)

R&D results: Application (or system) development

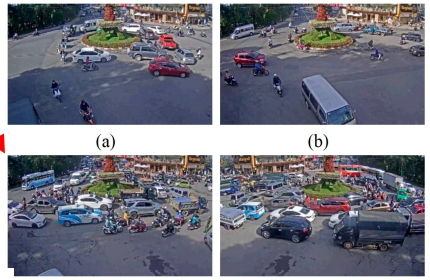
Smart environmental-mobility (DLU)



Map-based Data Visualization



Air pollution & weather data



Video data

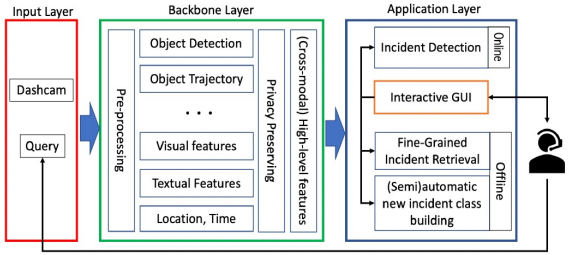
Public dataset

Smart sustainable city

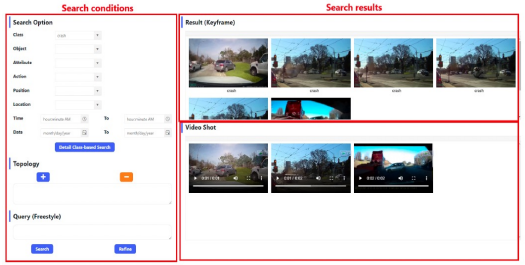
Risk map (app)

Community Dengue Early Warning System (ISU)

MM-trafficEvent (NICT): Incident detection and retrieval from dashcams DB



Framework

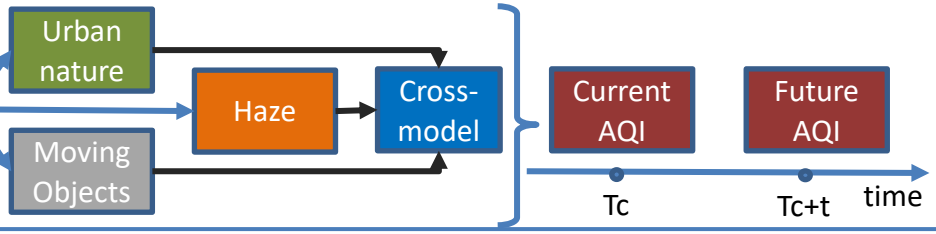


Interactive GUI

Haze transboundary Prediction (UTB)

MM-Mobility-AQI (NICT): Anticipate Future AQI based on visual pollution

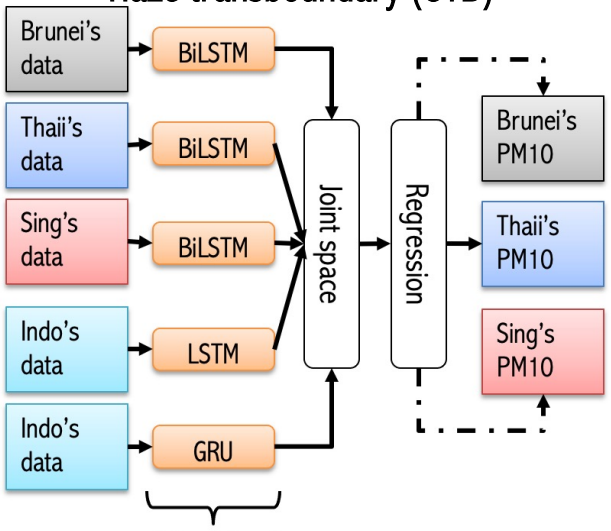
Image at Tc

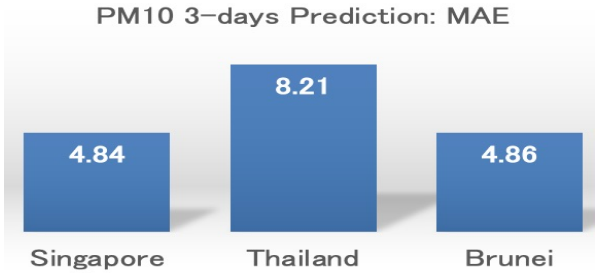


Benchmark: Insights for wellbeing challenge in Haze Transboundary

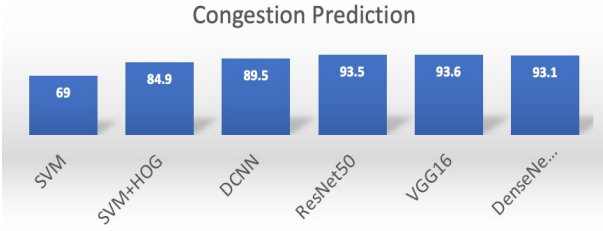
R&D results: Experiments including field testing

Haze transboundary (UTB)



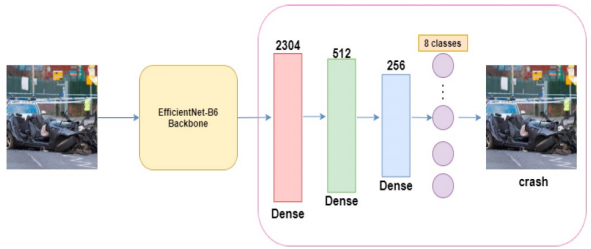


Smart environmental-mobility (DLU)



Congestion Prediction using CCTV data

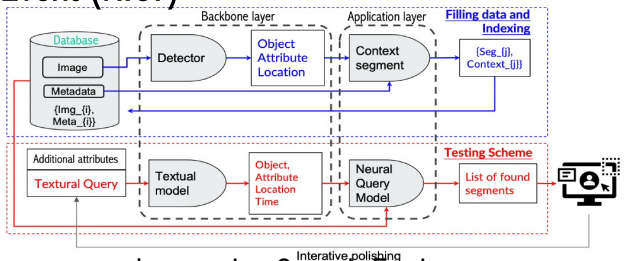
MM-trafficEvent (NICT)



Incident detection model

Incident	F1-score (ours)	F1-score([26])
Animals	**0.9701**	0.9021
Collapse	**0.9455**	0.9174
Crash	**0.9681**	0.9394
Fire	0.9697	**0.9848**
Flooding	**0.9742**	0.8806
Landslide	**0.9351**	0.9028
Snow	**0.9916**	0.9689
Treefall	**0.9787**	0.9241

Incident detection Results

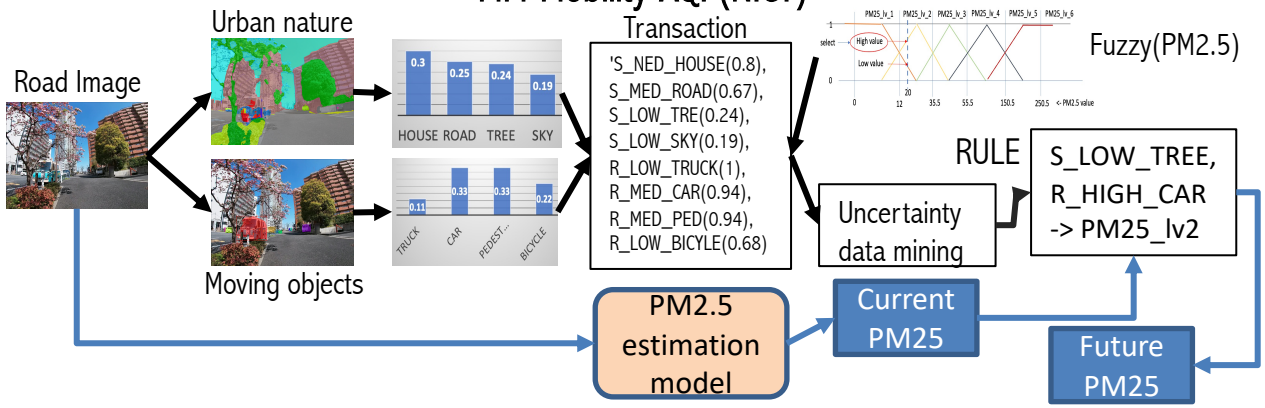


Interactive Search Engine

Parameter	Value
RetroTruck and I4W datasets	854 videos (1 ~ 15 mins/each)
Number of Queries	50
Evaluation Metric	P@10
Average result by naive user	Avg(P@10) = 7.18/10 ≈ 72%
Average result by expert user	Avg(P@10) = 7.56/10 ≈ 76%
Average finding-loops by naive user	15.3
Average finding-loops by expert user	10.8

Fine-grained incident detection Result

MM-Mobility-AQI (NICT)



Estimation and Prediction Accuracy

Dataset	Estimation Accuracy	Prediction Accuracy
ND_Hien	0.6403	0.9384
MNR-HCM	0.7679	0.9022
Tokyo	0.99	0.8131
VisionAir India	0.8421	0.7343

Pattern: S_low_tree S_low_sky S_high_road PM25_lv4
R_high_motobike :[4819, 1779]
-> if there are lots of motobike running on a road with few trees, PM25 can reach level 4. And if PM25 is level 4, after 1779 period, it happens again

Project Activities: Budget plan in detail

1. 22K USD is located to DLU to set up the network of ten environment-weather stations across Dalat city, Vietnam.
2. 10K USD is provided to NUS to create the software of QGIS
3. 4K USD is located to UTB to buy equipment for collecting road incident data.
4. 4k USD is provided to ISU to finish their IoT OL trap

R&D results: Scientific and technological

1. Values and Complex Events Prediction
   - MM-trafficEvent: Automatically create a new incident class and Detect incident from dashcam videos.
   - MM-Mobility-AQI: Predict environmental quality using transfer learning and uncertain temporal transaction data mining.
   - MM-trafficNET: Predict congestions using GNN techniques on CCTV database (videos).
   - MMM-hazePrediction: Predict air pollution using Multi-Attention Spatio-Temporal Graph Networks on Tokyo peripheral dataset (air pollution, weather)
2. Insights from cross-data
   - Mining of Periodic-Frequent Patterns in Very Large Uncertain Temporal Databases, applied for Tokyo and Vietnam environment-visual dataset. The patterns can reason the association between urban nature, moving vehicles, and air pollution.
3. Decentralized and collaborative development
   - Transferred Learning: Utilize transfer learning models developed by NICT to partners on local datasets.
   - MM-sensing system: the integration system to connect personal multimedia devices, xData Edge (local servers) and xData PF for predicting events (e.g., AQI, congestion)
4. Data Visualization and Geo-based Navigation
   - A risk-avoidance navigation system based on the outputs mentioned models and algorithms for sustainable smart cities

Scientific Contribution: Presentations at International Conferences

No	Paper title:	Author names	Affiliation	Conference name	The date of the conference	The venue of the conference
1.	Image-2-AQI: Aware of the Surrounding Air Qualification by a Few Images	**Minh-Son Dao***, K. Zettsu, Rage Uday Kiran	*NICT	IEA/AIE	26-29/07/2021	Virtual Conference
2.	MNR-Air: An Economic and Dynamic Crowdsourcing Mechanism to Collect Personal Lifelog and Surrounding Environment Dataset. A Case Study in Ho Chi Minh City, Vietnam	D.H. Nguyen, T.L.. Nguyen-Tai, M.T. Nguyen, T.B. Nguyen, **Minh-Son Dao***	*NICT	MMM	22-24/01/2021	Virtual Conference
3.	An Effective AQI Estimation Using Sensor Data and Stacking Mechanism	Q.D. Duong, M.Q. Le, T.L. Nguyen-Tai, D.H. Nguyen, **Minh-Son Dao***, T.B. Nguyen	*NICT	SoMET	21-23/09/2021	Virtual Conference
4.	Discovering Spatial High Utility Itemsets in High-Dimensional Spatiotemporal Databases	S.C. Bommisetty, P. Ravikumar, R. Uday Kiran, **Minh-Son Dao***, Koji Zettsu	*NICT	IEA/AIE	26-29/07/2021	Virtual Conference
5.	Efficient Discovery of Partial Periodic-Frequent Patterns in Temporal Databases	S. Nakamura, R. Uday Kiran, L. Palla, P. Ravikumar, Y. Watanobe, **Minh-Son Dao***, K. Zettsu, M. Toyoda	*NICT	DEXA	27-30/09/2021	Virtual Conference
6.	ICDAR@ICMR 2021: Proceedings of the 2021 Workshop on Intelligent Cross-Data Analysis and Retrieval	**Minh-Son Dao*,** D.T. Dang-Nguyen, M. Riegler	*NICT	ICMR – ICDAR workshop	16-19/11/2021	Virtual Conference

Scientific Contribution: Presentations at International Conferences

No	Paper title:	Author names	Affiliation	Conference name	The date of the conference	The venue of the conference
7.	Overview of MediaEval 2021: Insights for Wellbeing Task : Cross-Data Analytics for Transboundary Haze Prediction	**Asem Kasem**, Minh-Son Dao*, Effa Nabilla Aziz****, D.T. Dang-Nguyen, C. Gurrin, M.T. Tran, T.B. Nguyen, **Wida Suhaili****	*NICT **UTB (Universiti Teknologi Brunei)	MediaEval	12-14/12/2021	Virtual Conference
8.	Discovering Periodic-Frequent Patterns in Very Large Uncertain Temporal Databases	L. Palla, R. Uday Kiran, **Minh-Son Dao***	*NICT	ICONIP	8-12/12/2021	Virtual Conference
9.	MM-trafficEvent: An Interactive Incident Retrieval System for First-view Travel-log Data	**Minh-Son Dao*,** Phu Nguyen, Duy Pham, Binh Nguyen, Koji Zettsu	*NICT	IEEE Big Data	15-18/12/2021	Virtual Conference

Published Journal Papers and Book Chapters

No:	Paper title:	Author names	Affiliation	Journal name	The publisher of the Journal	The volume number and Pages
1.	Research on Traffic Congestion Detection from Camera Images in a Location of Dalat	**Nguyen Thi Luong*****	***DLU (Dalat University)	Dalat University Journal of Science	Dalat University, Vietnam	Volume 11, Issue 4, 2021 pp. 63-75
2.	[*Book Chapter*] Insights for Urban Road Safety: A new Fusion-3DCNN-PFP Model to Anticipate Future Congestion from Urban Sensing Data	**Minh-Son Dao***, R.Uday Kiran, Koji Zettsu	*NICT	[*Edited book*] Periodic Pattern Mining: Theory, Algorithms, and Applications	Springer Singapore	Hardcover ISBN978-981-16-3963-0 eBook ISBN978-981-16-3964-7

Scientific Contribution: Social Impacts

1. Open public datasets:
   - Haze Transboundary: ASEAN Archives of weather and air pollution data.
   - Environment-visual datasets in Dalat city, Vietnam: Dalat city archive of weather, air pollution, and CCTV videos.
2. Challenges:
   - MediaEval 2021 Insight for Wellbeing: Cross-Data Analytics for (transboundary) Haze Prediction (https://multimediaeval.github.io/editions/2021/tasks/wellbeing/)
     - 10 teams registered
3. Conference special session and workshops:
   - ICMR2021 workshop on Intelligent cross-data analytics and retrieval (ICDAR) (https://www.xdata.nict.jp/icdar_icmr2021/index.html)
     - 17 submitted papers, 5 accepted regular papers, and 4 short papers.
     - 1 keynote , 1 invited talk, and 1 panel.
   - MMM2022 Special session on Multimedia Analytics for Contextual Human Understanding (MACHU) (http://mmm2022.org/ssp.html#machu)
     - 7 submitted papers

Conclusion:

1. **Scientific and technological**
   - Researched and developed several topics and methods that contribute to the success of the project including haze transboundary prediction on ASEAN area data, interactive incident retrieval in dashcam videos, periodic frequent patterns mining, air pollution estimation and prediction using images, and safe route navigation planning.
2. **Application (or system) development**
   - MM sensing system (including MM-trafficEvent, MM-trafficNet, MM-mobility-AQI)
   - A risk-avoidance navigation system
   - Dengue Early Warning System architecture
   - APIs library and manual instruction website
3. **Experiments including field testing**
   - Evaluated (transferred) haze transboundary prediction models in ASEAN dataset
   - Evaluated MM-trafficEvent in Tokyo, Dalat city, and youtube datasets
   - Evaluated MM-mobility-AQI in Tokyo, Dalat city, and India datasets.
   - Evaluated risk map in Dalat city dataset
   - Evaluated MM-trafficNet in Dalat city dataset
4. **Datasets**
   - Tokyo environment-lifelog dataset
   - Dalat city environment-lifelog-tourism-CCTV dataset
   - Cauayan city Dengue dataset
   - ASEAN environment-air pollution dataset

Future works:

1. Scientific and technological
   - Continue ongoing scientific and technological purposes mentioned above
   - Research and Develop more topics and methods focusing on improving the smart of data, the flexible ability of Reusable, Sharable, and Transferable of the system.
2. Application (or system) development
   - Smart environmental Tourism and Sustainable Mobility for Dalat city, Vietnam
   - Smart Dengue Early Warning System for Cauayan City, Philippines
   - Smart Outdoor Activities for Singapore
   - Transboundary Air-Pollution Forecasting for ASEAN countries
   - Open dataset for open science data community
   - Completed xDataPF – xDataEdge and MM sensing system with high privacy protection
3. Experiments including field testing
   a) Field experiment of environmental quality data collection by residents using MM sensing and customization of short-term prediction of environmental quality of tourist spots (Dalat City, Vietnam) and environmental health (Cauayan City, Philippines) using collected data.
   b) Benchmarking to attract the attention from industry-academy-government on environment-human topics, expected to be organized in NUS