行政院所屬各機關因公出國人員出國報告書
（出國類別：其他）

參加 2023 年國際通訊網路及應用會議 (International Telecommunication Networks and Applications Conference, ITNAC 2023)

服務機關：環境部
姓名職稱：王士榮分析師、黃柏禎分析師
派赴國家：澳大利亞
出國期間：**112** 年 **11** 月 **27** 日至 **12** 月 **2** 日
報告日期：**113** 年 **3** 月

摘要

本部致力應用新興科技輔助環境監測，貫徹開放政府精神，透過空氣品質監測網、環境即時通及空氣網等多元管道向大眾揭露即時監測資訊，並以環境資料開放平台提升數據加值應用。為與各國專家學者分享與交流，提升國際能見度，展現我國環境監測及數據加值應用成果，以「A Deep Learning-based Air Quality Index Prediction Model using LSTM and Reference Stations:A Real Application in Taiwan」為題投稿國際通訊網路及應用會議 (International Telecommunication Networks and ApplicationsConference, ITNAC)，並獲審核受，爰由本部派員參加實體會議並進行簡報報告，與各國家專家學者分享我國空品資料應用成果。

本會議由澳大利亞皇家理工大學主辦，主席為 Mark Gregory 教授，邀請世界各國學術與研究人員與會，進行方式以會前投稿並獲接受之論文作者進行簡報說明。本次研討會分成兩組 12 場次，由論文投稿單位口頭發表後進行發問及交流，與會人員可自由選擇感興趣的議題參加。本次論文主題相當豐富，包含「綜合性議題」「網路」「無線網路物聯網」「網路通訊」「網路架構設計」及「無線網路安全」等各式主題。本部論文發表為第二日（11 月 30 日），同日亦有多篇與環境監測相關論文，透過討論交流與各國環境相關研究人員互動。

此外，本次主辦單位另安排 1 場工作坊、4 場專題演講及 1 場參訪活動，讓參加人員除了自身的研究領域外，得以使用更宏觀的角度來看待資訊科技的發展，不論對於研究人員或者政府機關，皆可提供更深入的思考。

目錄

壹、 目的及背景說明

一、 國際通訊網路及應用會議 (International Telecommunication Networks and Applications Conference, ITNAC)

國際通訊網路及應用會議(International Telecommunication Networks and Applications Conference, ITNAC)由澳大利亞皇家墨爾本理工大學(Royal Melbourne Institute of Technology，RMIT)工學院主辦，旨在探討和蒐集來自學術界、公務界、業界和標準化機構高度創新和最先進的研究成果，提供研究人員和工程師展示和討論最先進的資訊科技、網路通訊技術、服務及應用等相關主題之交流平台。

歷次會議主要舉辦地點為澳大利亞與紐西蘭，2023 年（第 35 屆）於澳大利亞墨爾本(Melbourne, Australia)舉辦，探討主題廣泛，包含「無線網路」「行動計算」「網際網路與通訊科技」「網路應用」「光纖通訊」「感測網路」及「網路管理」，主辦單位亦鼓勵「行動 IPv6」「車載網路」及「新興科技」等不同主題投稿，提供新興領域議題展示與討論機會。

二、 會議目的

本部於全台各地設置國家級空氣品質監測站，累積監測資料超過 30 年，迄今全台各地已有固定式 78 站、移動式 10 站，監測資料經過本部嚴格管理規範，具有很高的資料品質，本部使用人工智慧技術，以機器學習方式採 LSTM 模型對歷史資料進行訓練，透過訓練完成的模型進行未來 12 小時空氣品質預測，建置資料加值應用典範，相關成果已應用於本部空氣品質監測網(https://airtw.moenv.gov.tw/)以及環境即時通 APP，提供民眾活動安排與公部門政策執行參考。

本部將預測方式以學術論文方式呈現，以 「A Deep

Learning-based Air Quality Index Prediction Model using LSTM and Reference Stations:A Real Application in Taiwan」為題投稿國際通訊網路及應用會議，獲審核後，爰由本部派員參加實體會議並進行簡報報告，並於會中、會後與各國家專家學者分享我國空品資料應用成果並進行意見交換。

貳、 會議行程說明

此次行程始於 112 年 11 月 27 日夜晚，由臺灣啟程飛往澳大利亞墨爾本，於 11 月 28 日（墨爾本當地時間）下午抵達，隨即前往下榻旅店安置隨身物品，並立即前往墨爾本皇家理工大學(Royal Melbourne Institute of Technology,RMIT)參加 2023 年國際通訊網路及應用會議開幕茶敘，由主席 Mark Gregory 教授致詞並說明後面三天的行程。本次研討會分成兩組 12 場次，由論文投稿單位口頭發表後進行發問及交流，與會人員可自由選擇感興趣的議題參加，此外還有 4 場專題演講及 1 場參訪活動。

11 月 29 日（墨爾本當地時間）在墨爾本皇家理工大學 16 號大樓(Storey Hall)舉行，上午為 2 場次論文發表會，主題包含行動通訊及無線網路計 10 篇論文以及 2 場專題演講；下午為 4 場次論文發表會，主題包含綜合性議題、網路、無線網路物聯網、網路通訊計 16 篇論文。

11 月 30 日（墨爾本當地時間）上午為 2 場次論文發表會及 1 場專題演講，主題為光網路通訊及物聯網，其中包含本部所發表論文「A Deep Learning-based Air Quality Index Prediction Model using LSTM and Reference Stations A Real Application in Taiwan」，由本部王士榮分析師簡報，並與黃柏禎分析師共同回應與會人員提問，下午至墨爾本板球場(Melbourne Cricket Ground, MCG)及運動博物館參訪，晚上並參加研討會舉行的晚宴。

12 月 1 日（墨爾本當地時間）上午為 2 場次論文發表會及 1 場專題

演講，主題包含物聯網綜合議題及網路安全計 10 篇論文，下午為 2 場次論文發表會，主題包含網路架構設計及無線網路安全計 9 篇論文。下午研討會結束後隨即由墨爾本返回臺北。

12 月 2 日早上順利抵達臺北，完成本次公務行程。

參、 會議內容及成果說明

一、 人工智慧及物聯網應用

(一) 複雜系統的簡單解決方案

墨爾本皇家理工大學 Xinghuo Yu 教授(IEEE Fellow)在本次研討會的專題演講中，針對現今時空複雜度很高的虛實世界應用需求，如何因應與簡化。其提出的核心理念是不要一味在各個層面都要求完整精確，而是要找出關鍵點，並在問題簡化與精確度求取平衡，藉以發展夠用、及時且可信賴的解決方案，這個理念可做為未來本部發展複雜環境資訊應用時的參考。

(二) 森林火災偵測應用

本次研討會有 2 篇有關森林火災偵測的應用，其中一篇分析比較了簡單卷積神經網路模型(Convolutional Neural Network)及 5 個預訓練模型(VGG16, ResNet50, MobileNetV2, Xception, and Inception)用於森林火災偵測應用的準確度，結果顯示 Xception 的模型效果較佳(Shouthiri Partheepan 等人)；另外一篇論文則介紹了一個多感應器火災偵測預警系統，藉由持續監測溫度、濕度及紅外線等環境資料來達到潛在火災熱點辨識的目的。

二、 通訊網路及資訊安全應用

(一) 切分學習(Split Learning)導致的資訊洩漏探討

在資源有限的物聯網及行動裝置及資料不適合分享、集中的應用中，切分學習是一項很有用的分散式深度學習模型技術，樂

卓博大學（La Trobe University）Naveen Chilamkurti 教授在本次研討會的專題演講中，分享了其研究團隊就切分學習(Split Learning)可能導致的資訊洩漏進行了探討，包含可能的攻擊及防禦等策略，可做為本部日後發展物聯網應用的參考。

(二) 旁路攻擊(Side-Channel Attack)與資料洩漏(Data Leakage)

旁路攻擊係指透過資訊設備運作時所揭露的額外資訊，如：時間資訊、功率消耗、電磁洩露或聲音等訊息痕跡，取得隱含的機敏資訊。隨著人工智慧的快速發展，類神經網路模型可能被用於旁路資訊攻擊以取得機敏資訊，人工智慧應用本身所包含的機敏資料也可能遭受旁路攻擊而洩露出去。本次研討會就有三篇論文進行相關議題的探討，凸顯了發展人工智慧應用並牽涉到機敏資料處理時，如何有效隱藏電磁軌跡等旁路資訊的重要性。

(三) 入侵偵測的分析與發展議題

本次研討會有多篇論文聚焦在資通訊、行動網路、無線網路安全及入侵偵測等資安議題，除了基礎資訊技術與安全相關理論探討，也包含一些實務面的應用發展，例如：針對不同入侵偵測工具結果的分析(Santanam Kasturi)、整合不同偵測工具藉以提升偵測及主動警示效率(Sarah Alharbi)及低頻率分散式阻斷攻擊(Row Rate Distributed Denial of Service)防護系統發展(Shijin Liu)。

(四) 分散式身分認證(Decentralized Identifier, DID)之於物聯網應用

在需要身分驗證的物聯網應用中，分散式的身份自主(Self-Sovereign Identity, SSI)驗證機制對這類應用的安全扮演了重要角色，但物聯網設備的有限資源侷限了這類機制的實現，Alessandro Pino 等人在本次研討會中提出了分散式身分認證結合會員證明(Proof of Membership)的解決方案，這個領域的後續

發展值得關注。

肆、 心得與建議

一、 心得：

(一) Yu 教授提及面對時空複雜度很高的虛實世界應用需求，不應一味在各個層面都要求完整精確，而是要找出關鍵點，並在問題簡化與精確度求取平衡。隨著各種資訊科技的突飛猛進，各項技術綜合之後，何謂最佳解對於公務機關來說或許不是最重要，只要能有效提供解決方案，都可以列入規劃，不掉落到鑽牛角尖的泥淖裡。

(二) 本次共有兩篇論文與本部監測業務相關，皆為監控森林火災之應用，雖我國森林火災情形不若其他面積遼闊國家頻繁，其相關概念及技術應用，亦可給予本部對於環境與數據變化之間的應用啟發。

(三) 透過參與國際研討會，我們能透過各界專家學者的口頭報告，快速獲得國外發展現況及技術資訊。且與期刊論文不同的是，會議論文為研究初期階段發表成果的重要方式，可以看到較多不同應用的發想，並且可以透過會中、會後的討論，與作者互動可更加深入其研究的想法，以及論文中所看不到的其他面向回饋。

(四) 有會議論文提及防火牆與交換器的資安防護規則，經過作者實際驗證，有時大量的防護規則不僅效能可能較差，也會導致大量計算資源的浪費。雖該論文相關論述與論證仍屬初期，惟其提供的啟發亦可應用於實際管理案例中，面對現今大數據的浪潮下，找出最重要的地方，才是維持系統高效的關鍵。

二、 建議事項

(一) 不同於本司發展應用時注重實作，研討會因傾向於學術上的研究，

例如兩篇研究相近的論文皆採用多種不同模型驗證，未來本部擴展應用人工智慧於各項應用時，建議規劃嘗試不同模型，以求得最適模型，提升服務品質。

(二) 有鑑於資訊安全攻擊手法日新月異，建議持續辦理資通安全教育訓練，鼓勵同仁進修取得資通安全專業證照及職能訓練證書並維持證書有效性，提升機關人員資通安全知能與資安意識。

(三) 透過實際參與國際會議，除增進國際視野外，對外語能力的提升也相當顯著，建議各單位未來可多參與人工智慧、物聯網及資安等技術仍在超速發展的領域之國際研討會，除可更快速了解最新技術發想與應用，可同步增進視野與能力。

附錄 1、論文簡報

環境部
Ministry of Environment

A Deep Learning-based Air Quality Index Prediction Model Using LSTM and Reference Stations: A Real Application in Taiwan

Shih-Jung Wang

Dept. of Monitoring and Information, MOENV of Taiwan

環境部
Ministry of Environment

OUTLINE

1. Introduction
2. Related Works
3. Methodology
4. Experiment and Analysis
5. Applications of Public Service
6. Conclusions and Future Works

環境部
Ministry of Environment

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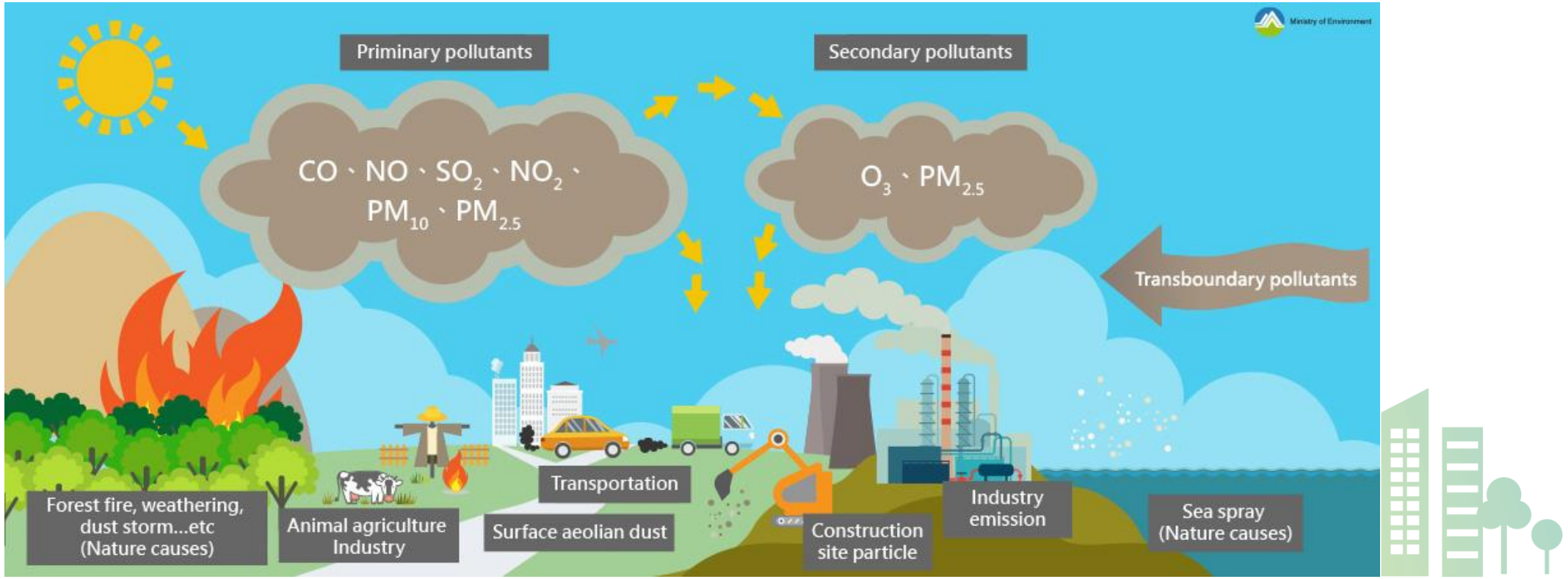
INTRODUCTION

INTRODUCTION

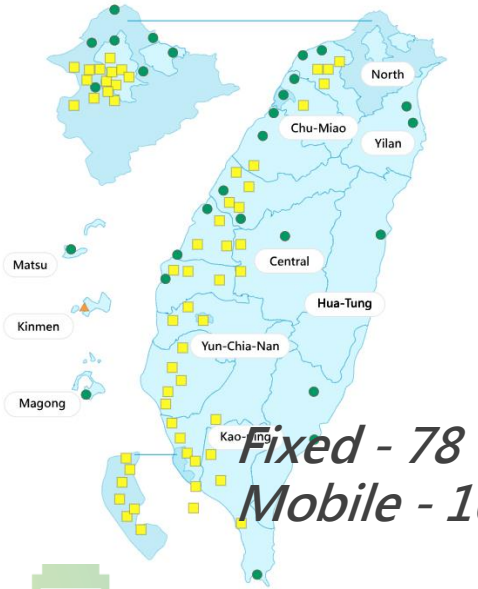
Air pollution have adverse effects on human health



INTRODUCTION

Air quality monitoring stations in Taiwan

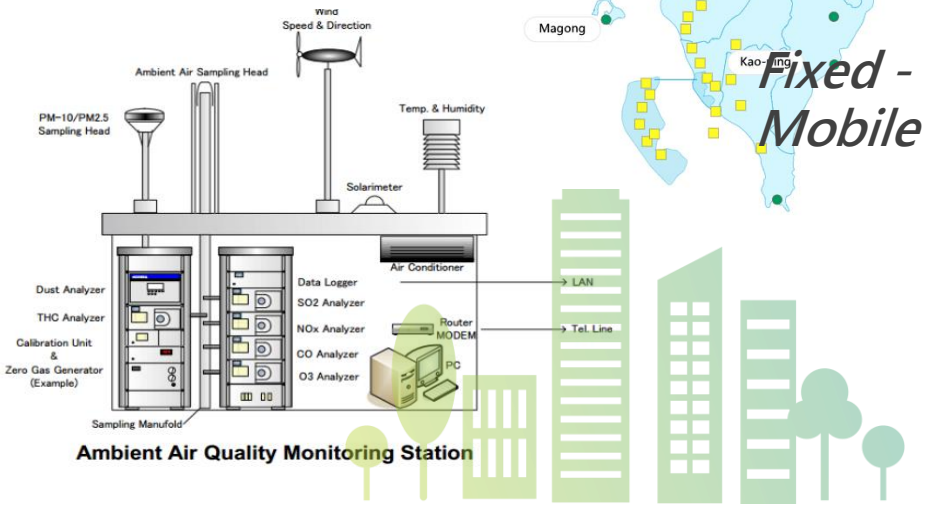
Major Pollutants - $PM_{2.5}$, PM_{10}, O_3, CO, NO_2, and SO_2



Fixed - 78
Mobile - 10

Other Monitoring Items

- THC
- NMHC
- CH_4
- NO_x
- NO
- UVA
- Rainfall
- Temperature
- Wind speed & direction



INTRODUCTION

Air Quality Index (AQI) - Level of impact

- Largest sub-indicator
- Leading pollutant

New Taipei/Fugue Cape

$PM_{2.5}$ ($\mu g/m^3$)	Moving Average	15
	Hourly Concentration	14
PM_{10} ($\mu g/m^3$)	Moving Average	30
	Hourly Concentration	36
O_3 (ppb)	8-hour Moving Average	48
	Hourly Concentration	67
CO (ppm)	8-hour Moving Average	0.10
	Hourly Concentration	0.17
SO_2(ppb)	Hourly Concentration	2.7
NO_2(ppb)	Hourly Concentration	1.5

A real case

Air Quality Index (AQI)

AQI	O_3 (ppm) 8h	O_3 (ppm) 1-h (1)	$PM_{2.5}$ ($\mu g/m^3$) 24-h	PM_{10} ($\mu g/m^3$) 24-h	CO (ppm) 8-h	SO_2 (ppb) 1-h	NO_2 (ppb) 1-h
Good 0 ~ 50	0.000 - 0.054	-	0.0 - 15.4	0-50	0 - 4.4	0-20	0-30
Moderate 51 ~ 100	0.055 - 0.070	-	15.5 - 35.4	51-100	4.5 - 9.4	21-75	31-100
Unhealthy for Sensitive Groups 101 ~ 150	0.071 - 0.085	0.125 - 0.164	35.5 - 54.4	101-254	9.5 - 12.4	76-185	101-360
Unhealthy 151 ~ 200	0.086 - 0.105	0.165 - 0.204	54.5 - 150.4	255-354	12.5 - 15.4	186-304 (3)	361-649
Very Unhealthy 201 ~ 300	0.106 - 0.200	0.205 - 0.404	150.5 - 250.4	355-424	15.5 - 30.4	305-604 (3)	650-1249
Hazardous 301 ~ 400	(2)	0.405 - 0.504	250.5 - 350.4	425 - 504	30.5 - 40.4	605-804 (3)	1250-1649
Hazardous 401 ~ 500	(2)	0.505 - 0.604	350.5 - 500.4	505-604	40.5 - 50.4	805-1004 (3)	1650-2049

INTRODUCTION

Air Pollution Control Act

- Emergency response measures

- Air quality prediction
  - Policy formulation
  - Environmental management

INTRODUCTION

Objective

- An ANN model framework for predicting hourly real-time AQI
- The coming 12 hours for all 78 air quality monitoring stations

The remainder of this paper

- Pollutant concentrations, meteorological data, and time parameters
- Target stations (the stations aimed to predict), neighboring stations, and outpost stations
- LSTM_ON vs XGB_NON

環境部
Ministry of Environment

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Related Works

Related Works

S. Sankar Ganesh et al.

- Multiple regression model (MLR)
  - batch gradient descent
  - steepest gradient descent
  - mini-batch gradient descent.
- Support vector regression (SVR)
- In the earlier work, the MLR model was used.

TABLE III
PERFORMANCE OF REGRESSION MODELS FOR DELHI

Model	MAE	MAPE	R	RMSE	IA
MLR(BGD)	10.89	5.85	0.982	13.82	0.989
MLR(SGD)	7.67	3.93	0.989	10.68	0.991
MLR(MBGD)	6.66	3.60	0.993	8.80	0.994
SVR	5.13	3.01	0.996	6.20	0.998

TABLE IV
PERFORMANCE OF REGRESSION MODELS FOR HOUSTON

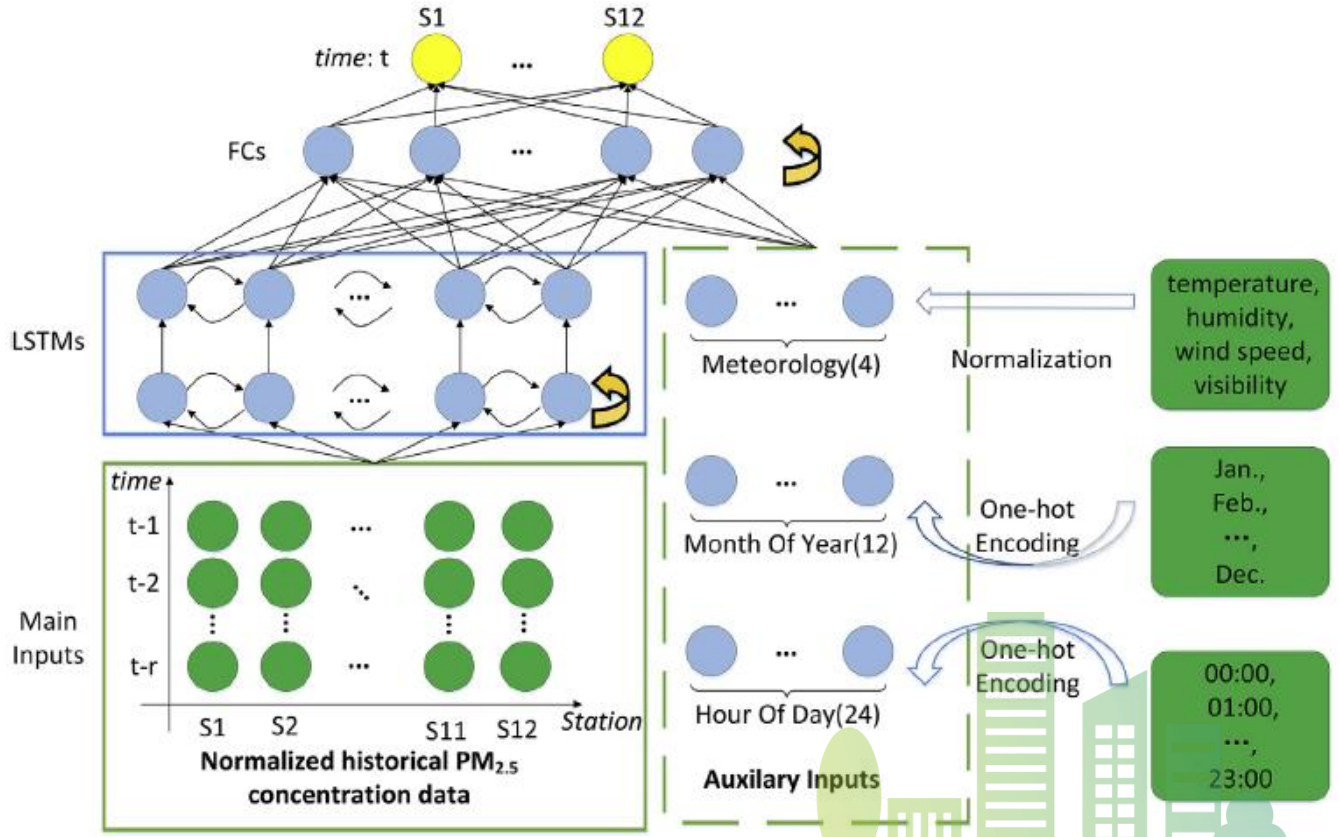
Model	MAE	MAPE	R	RMSE	IA
MLR(BGD)	10.46	12.34	0.929	13.06	0.960
MLR(SGD)	10.28	12.11	0.931	12.92	0.962
MLR(MBGD)	9.11	10.13	0.931	10.90	0.963
SVR	5.91	7.16	0.979	7.25	0.988

The investigated performance measures of all the regression models

Related Works

Li et al.

- Applying LSTM
- Divided into two parts
  - The first part
    - Historical $PM_{2.5}$ data
  - The second part
    - Meteorological data and time data
- The outputs from the two were merged
- It focuses solely on $PM_{2.5}$

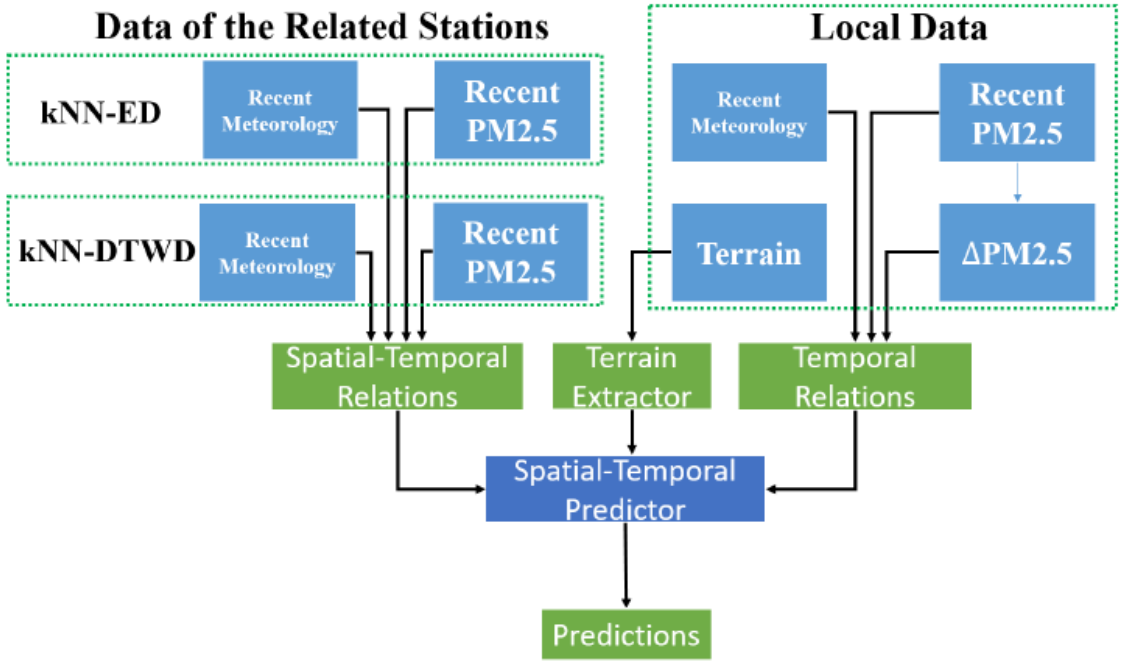


Network framework of the LSTME model for air pollutant concentration prediction.

Related Works

Soh et al.

- Dynamic time warping (DTW) and Euler's formula - the closest temporal feature
- STR(Spatial-Temporal Relations) : extract air quality features
- TE(Terrain Extractor) : neighboring terrains
- LSTM
- Implementation challenges and resource consumption

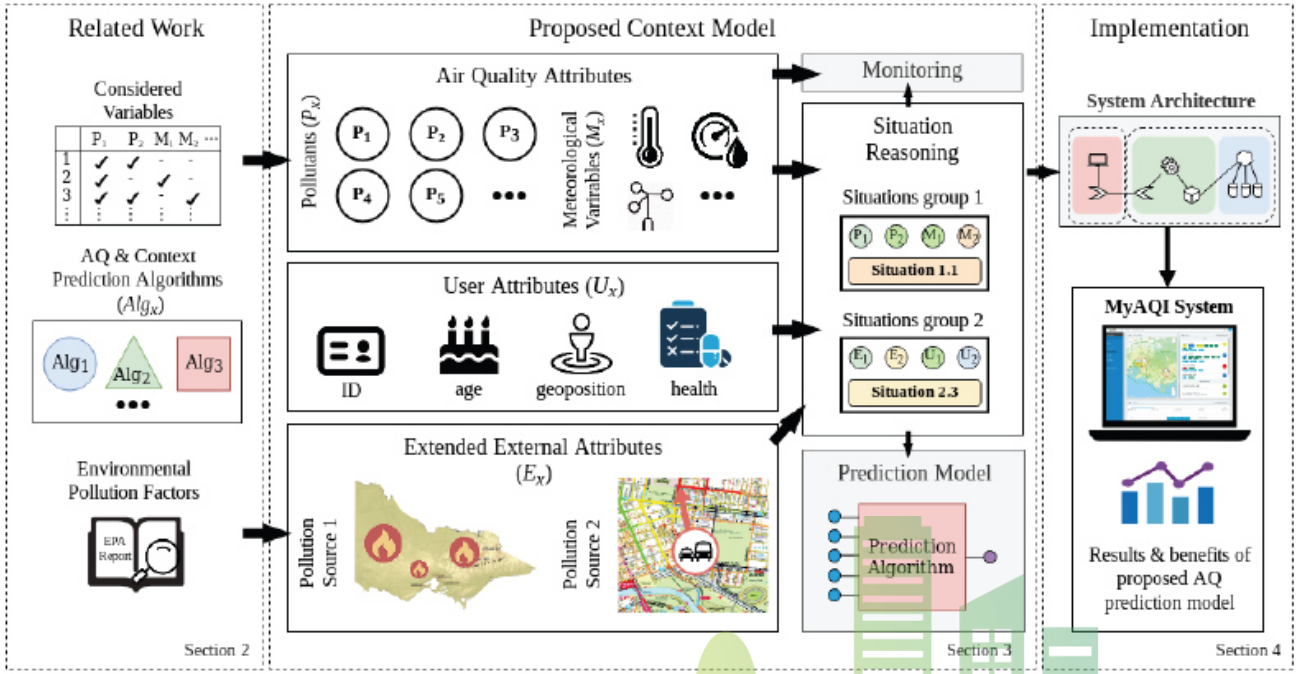


Predictive model (ST-DNN) framework.

Related Works

Daniel Schürholz et al.

- Pollution and meteorological data for model training
- A novel approach by merging aforementioned common data with context-aware computing
- Based on LSTM
- A real-world system conducting experiments in Australia.



Graphical Abstract

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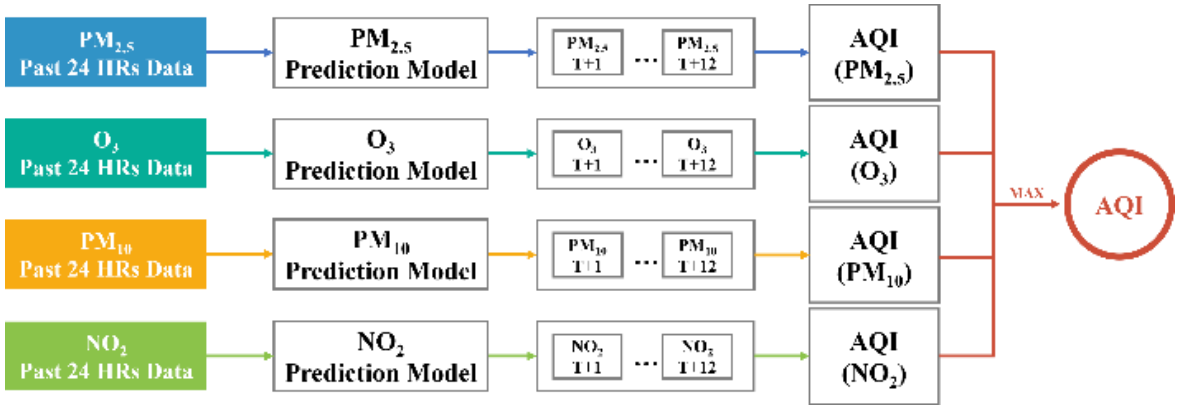
03 /

METHODOLOGY

METHODOLOGY

Problem Definition

- Predicting the AQI for the coming 12 hours(hourly basis)
- All 78 fixed stations, independent prediction model
- Inputting 24 hours data
- Not directly producing predicted AQI values
- $PM_{2.5}$, PM_{10}, O_3 and NO_2 were individually forecast

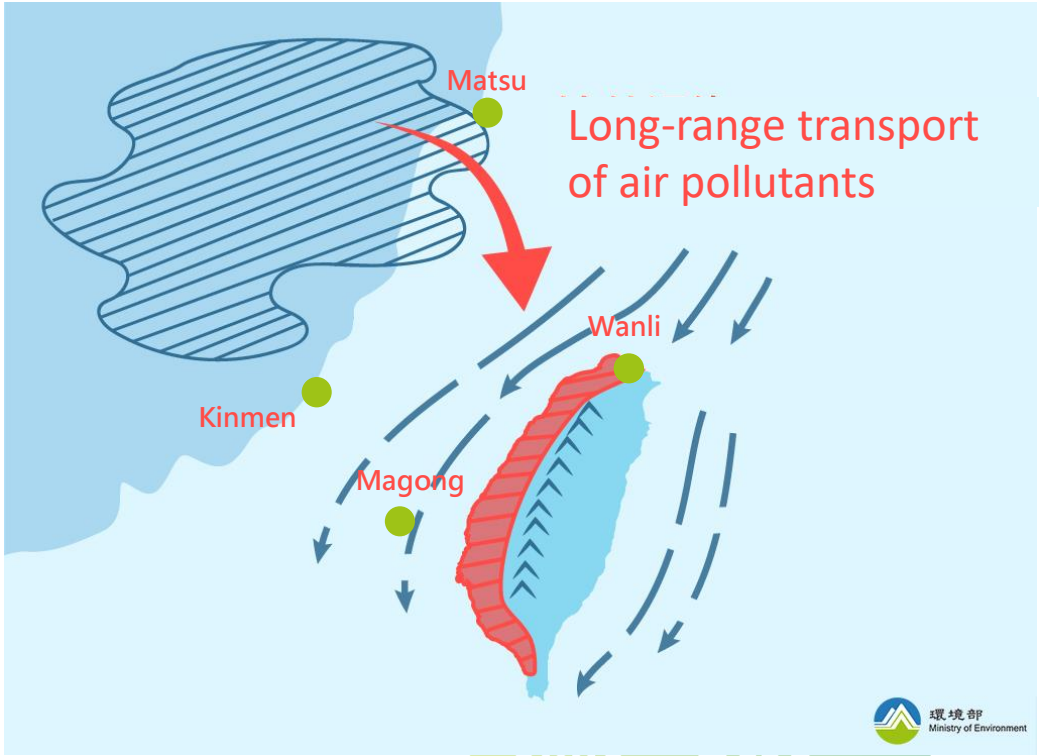


The calculation steps for predicting AQI

METHODOLOGY

Selection of Model and Reference Stations

- LSTM
  - Time series
  - Excellent results in many studies
- Neighboring stations
  - Within a 20-kilometer radius
- Outpost stations
  - Kinmen
  - Matsu
  - Magong
  - Wanli



METHODOLOGY

Features and Architecture

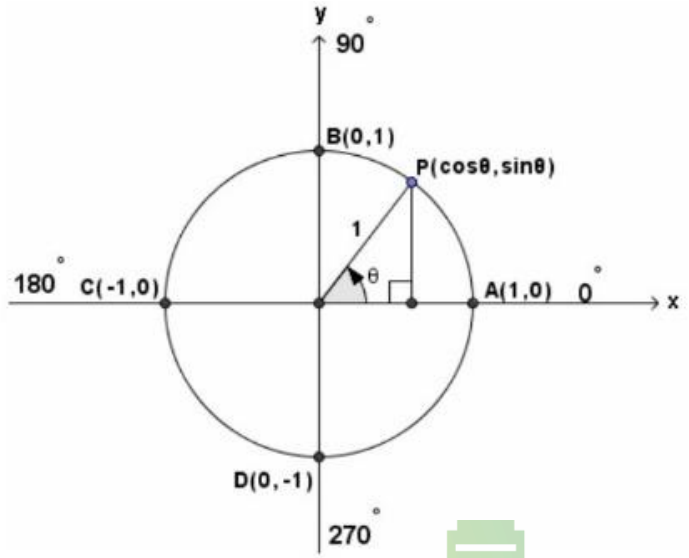
- Target station
  - CO, O_3, NO_2, NO_X, $PM_{2.5}$, PM_{10}, and SO_2
  - Humidity, wind speeds, wind directions, and temperatures

- Neighboring stations & Outpost stations
  - Only wind speeds, wind directions, and predicted pollutant concentrations

METHODOLOGY

Features and Architecture

- Continuity
  - Temporal
    - From 11 PM to 1 AM
    - From December 31st to January 1st
  - Wind direction
  - Difference between 360 degrees and 1 degree

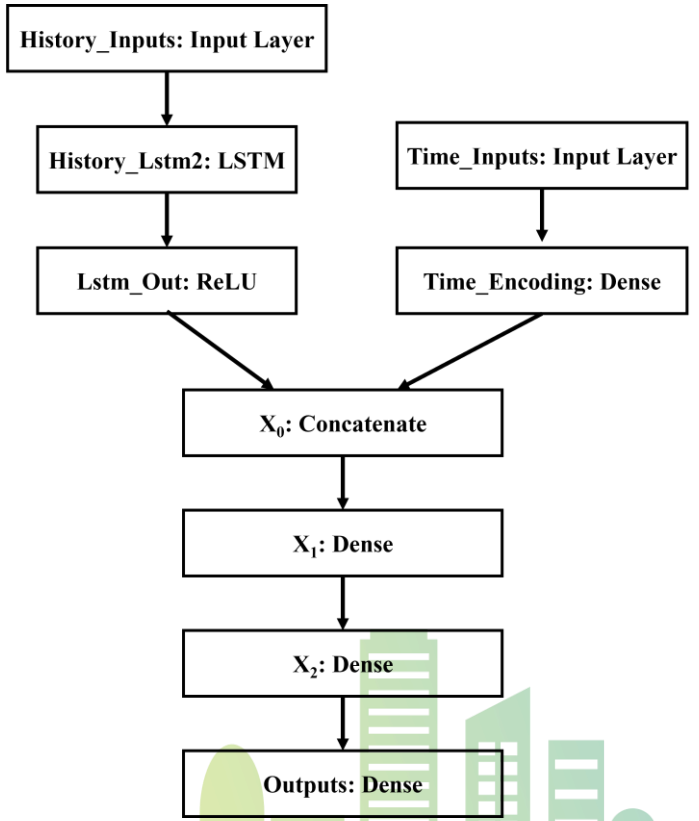


Trigonometric function transformations

METHODOLOGY

Features and Architecture

- Parameters - Grid search process
- Historical data
  - 1st hidden layer(LSTM) : 64 units
  - 2nd hidden layer(ReLU)
- Time data
  - Dense layer : 16 units
- After transformation and merging
  - Dense hidden layers : 128 units
    - ReLU, SGD
    - Learning rate : 0.01
    - Clip value : 1
- Training process
  - Epochs : 25
  - Batch size : 32



Architecture of LSTM_ON

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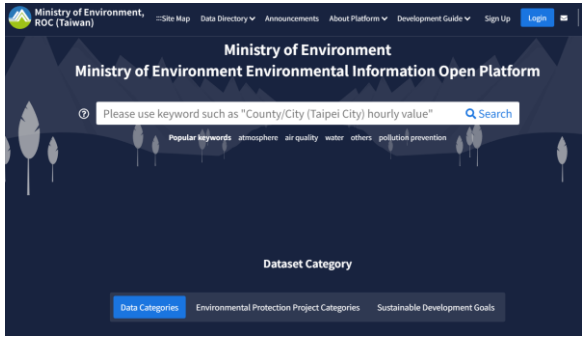
Experiment and Analysis

EXPERIMENT AND ANALYSIS

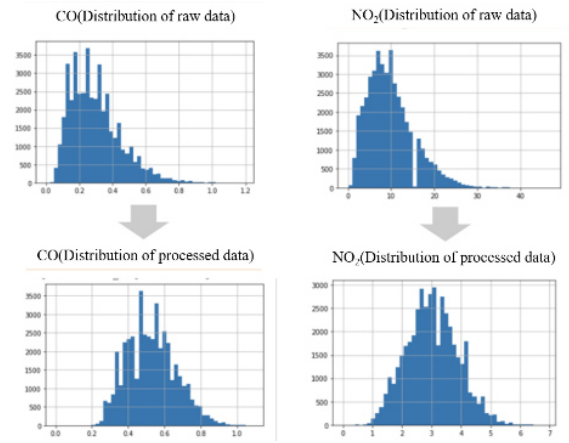
Data Set

- Environmental Information Open Platform
- Transformations
  - Root transformation included: CO, NO_2
  - Logarithmic transformations included PM_{10}, SO_2, rainfall, $PM_{2.5}$

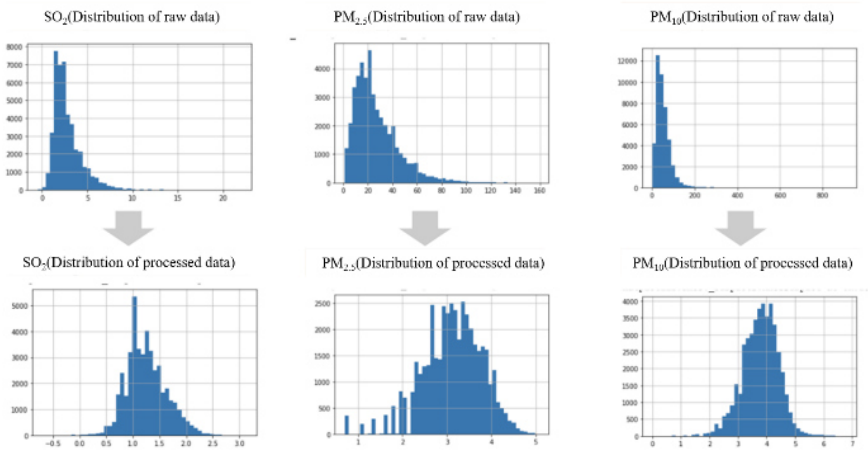


Official open data website of MOENV

Kaggle



Distribution - CO and NO_2

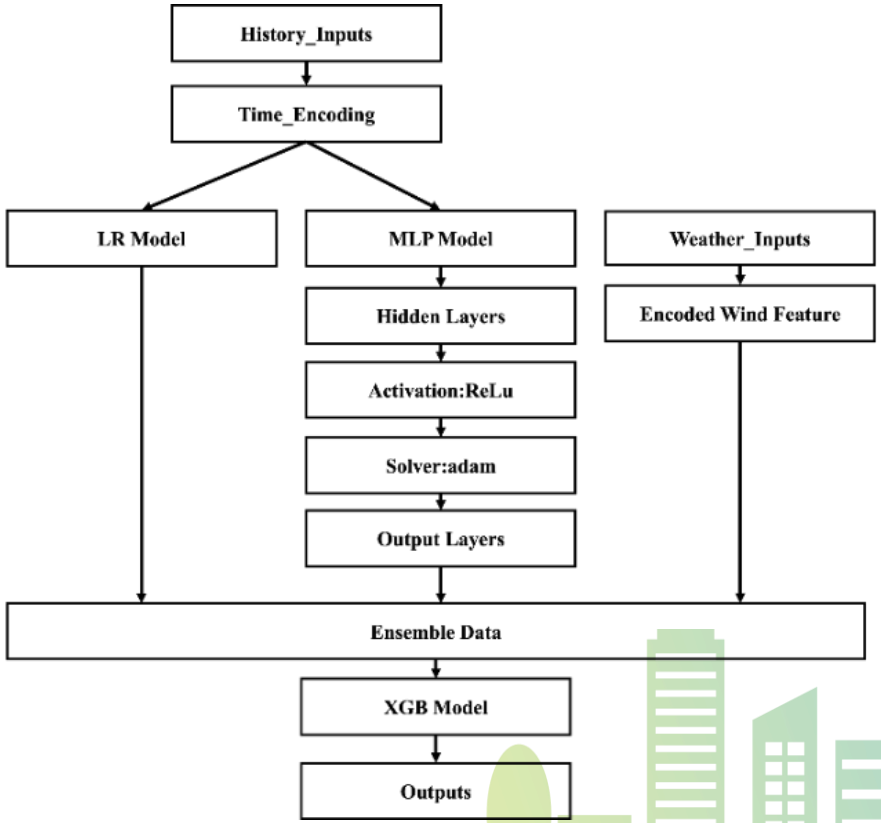


Distribution - SO_2, $PM_{2.5}$ and PM_{10}

EXPERIMENT AND ANALYSIS

XGB_NON

- Originally used
- Pollutant concentrations and Meteorological data
- Linear regression, MLP regressor
- Output results were combined with meteorological data
- Did not incorporate data from neighboring or outpost stations



Architecture of XGB_NON

Experiment and Analysis

Metrics

Mean Absolute Error (MAE)

$$P = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

y_i : prediction for the next i_{th} hour

x_i : ground truth for the next i_{th} hour

N : the number prediction with a time interval

Level Accuracy

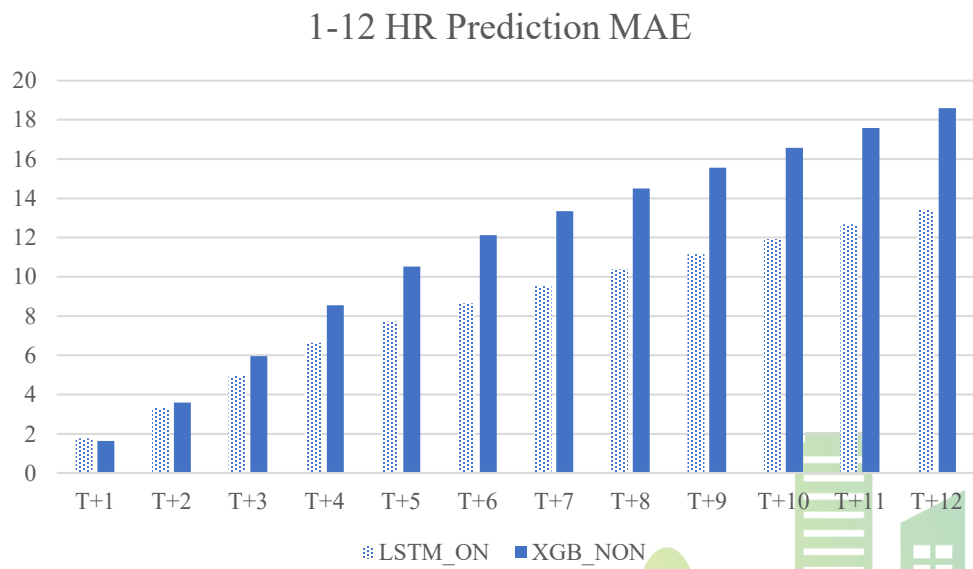
- Identical : Hit
- Distinct : Miss

AQI	0-50	51-100	101-150	151-200	201-300	301-500
Air Quality Index Levels of Health Concern	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	Hazardous
Status Color	Green	Yellow	Orange	Red	Purple	Maroon

Experiment and Analysis

Performance

- Train : 2018-2019
- Verify : January 2020
- 1-hour prediction
  - LSTM_ON - 1.76
  - XGB_NON - 1.63
- 6-hour prediction
  - LSTM_ON – 8.65
  - XGB_NON – 13.41
- 12-hour prediction
  - LSTM_ON – 12.11
  - XGB_NON – 18.59



EXPERIMENT AND ANALYSIS

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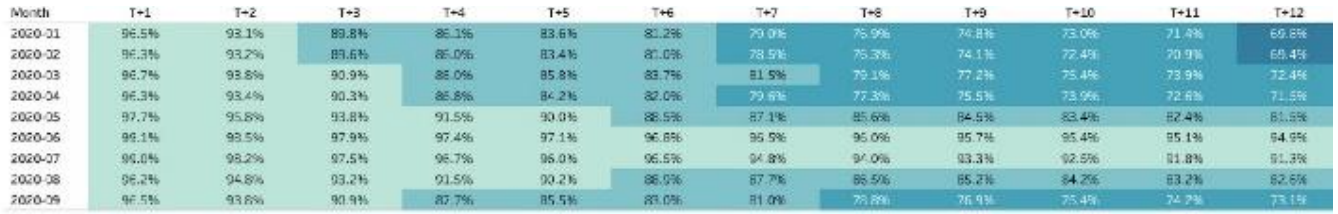
Performance

- January to September 2020
  - 1-4 hours : around 90%
  - May to August : 80% up
  - Remaining months : 70% up
  - Average : 86%
- Different training data
  - March to June 2021
  - 1-4 hours : 94% and 93.9%
  - 5-8 hours : 86.9% and 86.4%
  - 9-12 hours : 82.8% and 80.9%



Month	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9	T+10	T+11	T+12
2020-01	96.5%	93.1%	89.8%	86.1%	83.6%	81.2%	79.0%	76.9%	74.8%	73.0%	71.4%	69.8%
2020-02	96.3%	93.2%	89.6%	86.0%	83.4%	81.0%	78.5%	76.3%	74.1%	72.4%	70.9%	69.4%
2020-03	96.7%	93.8%	90.9%	88.0%	85.8%	83.7%	81.5%	79.1%	77.2%	75.4%	73.9%	72.4%
2020-04	96.3%	93.4%	90.3%	86.8%	84.2%	82.0%	79.6%	77.3%	75.5%	73.9%	72.6%	71.5%
2020-05	97.7%	95.8%	93.8%	91.5%	90.0%	88.5%	87.1%	85.6%	84.5%	83.4%	82.4%	81.5%
2020-06	98.1%	96.5%	97.9%	97.4%	97.1%	96.8%	96.5%	96.0%	95.7%	95.4%	95.1%	94.9%
2020-07	96.0%	98.2%	97.5%	96.7%	96.0%	96.5%	94.8%	94.0%	93.3%	92.5%	91.8%	91.3%
2020-08	96.2%	94.8%	93.2%	91.5%	90.2%	88.9%	87.7%	86.5%	85.2%	84.2%	83.2%	82.6%
2020-09	96.5%	93.8%	90.9%	87.7%	85.5%	83.0%	81.0%	78.8%	76.9%	75.4%	74.2%	73.1%

Level accuracy of LSTM_ON from January to September 2020

	Month	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9	T+10	T+11	T+12
2018-2019	2022-03	95.9%	92.0%	88.0%	83.5%	80.8%	78.3%	76.0%	73.7%	71.5%	69.6%	67.4%	65.8%
	2022-04	96.5%	93.5%	89.8%	86.1%	83.8%	81.6%	79.7%	77.6%	75.7%	74.2%	72.7%	71.3%
	2022-05	98.4%	97.0%	95.3%	93.6%	92.4%	91.3%	90.2%	89.0%	87.8%	86.4%	85.2%	84.1%
	2022-06	99.4%	98.8%	98.2%	97.8%	97.5%	97.3%	97.0%	96.7%	96.3%	95.9%	95.7%	95.3%
	平均	97.6%	95.3%	92.8%	90.2%	88.6%	87.1%	85.7%	84.2%	82.8%	81.5%	80.3%	79.1%
2019-2020	Month	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9	T+10	T+11	T+12
	2022-03	96.0%	92.2%	87.9%	83.6%	80.9%	78.6%	76.5%	74.6%	72.9%	71.3%	69.8%	68.5%
	2022-04	96.5%	93.3%	89.7%	86.3%	84.2%	82.2%	80.5%	78.8%	77.3%	76.0%	74.7%	73.3%
	2022-05	98.5%	96.9%	95.2%	93.4%	92.4%	91.5%	90.6%	89.8%	89.0%	88.2%	87.5%	86.9%
	2022-06	99.3%	98.7%	98.3%	97.9%	97.8%	97.7%	97.6%	97.6%	97.5%	97.5%	97.5%	97.5%
	平均	97.6%	95.3%	92.8%	90.3%	88.8%	87.5%	86.3%	85.2%	84.2%	83.2%	82.4%	81.5%

LSTM_ON with different training data of time periods

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05

Applications of Public Service

Applications of Public Service

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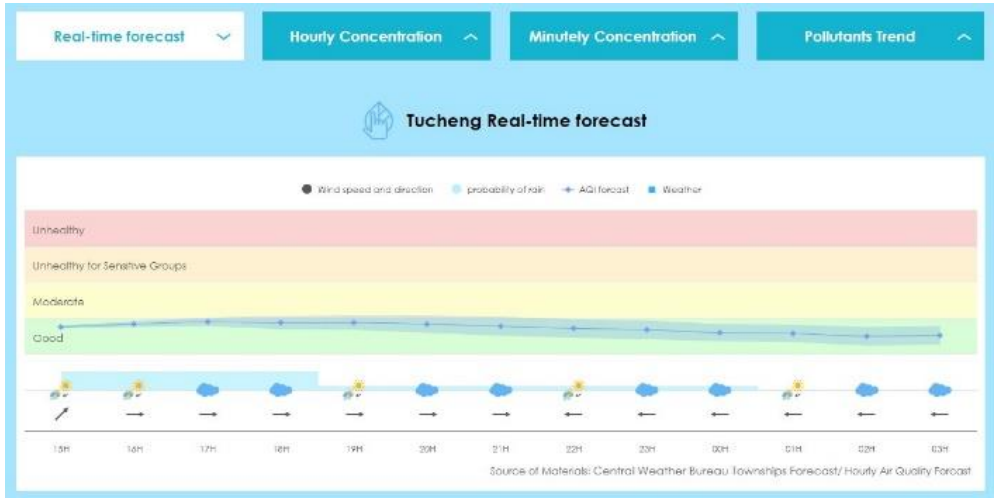
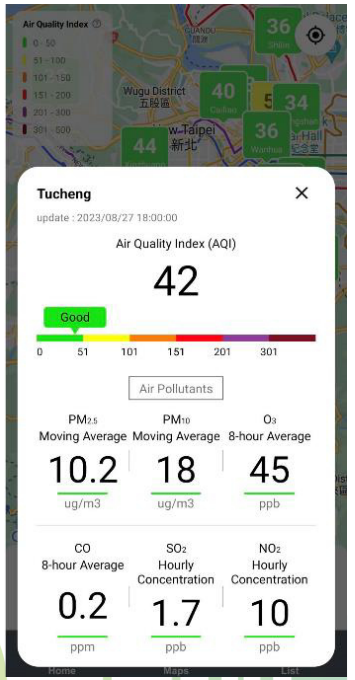
Taiwan Air Quality Monitoring Network



Environment Info Push App



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06

Conclusions and Future Works

Conclusions and Future Works

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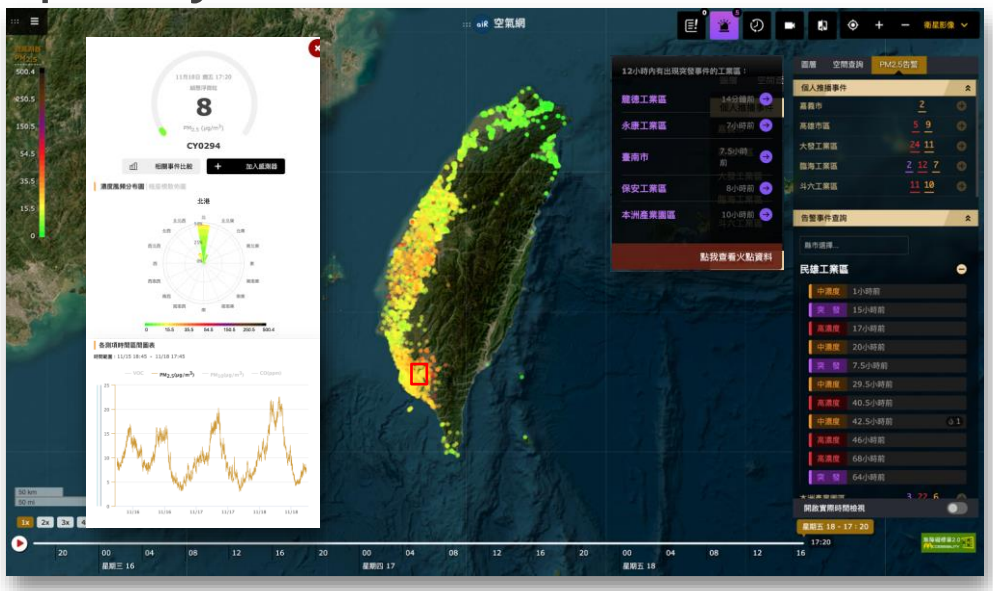
Conclusion

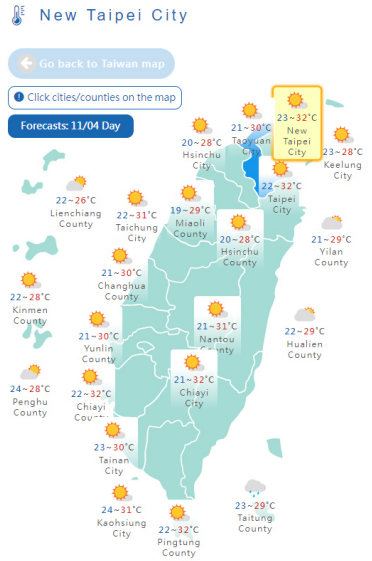
- This paper presents a neural network model constructed by using LSTM.
- Experimental results demonstrated the effectiveness of this approach in enhancing prediction accuracy and providing early forecasts of long-range transport of air pollutants
- This prediction model is applied within the Taiwan Air Quality Monitoring Network and the Environment Info Push app

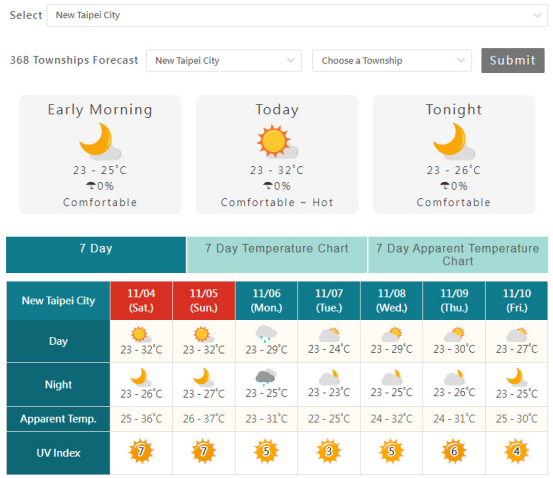
Conclusions and Future Works

Future Works

- Integrating meteorological forecast data
- Up prediction length- 48 hours
- Inputting micro-sensors
- Water quality







Cities/Counties Forecast(CWA)

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Thank you

附錄 2、發表論文

A Deep Learning-based Air Quality Index Prediction Model Using LSTM and Reference Stations: A Real Application in Taiwan

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***Abstract*—Air pollution has attracted significant attention as a public concern, prompting government efforts towards air quality monitoring. With the accumulation of data, the feasibility of utilizing artificial intelligence (AI) to aid in air quality prediction has grown. Air quality prediction plays a pivotal role in policy formulation and environmental management. We propose a neural network model framework constructed using LSTM (Long Short-Term Memory) model and fully connected model. It employs pollutant and meteorological data from target stations, neighboring stations, and outpost stations as feature factors. By utilizing the previous 24 hours monitoring data, it predicts the hourly air quality index (AQI) for the next 12 hours. Experimental results demonstrated the effectiveness of this approach in enhancing prediction accuracy and providing early forecasts of long-range transport of air pollutants. This prediction model is applied within the Taiwan Air Quality Monitoring Network [1] and the Environment Info Push app [2] both maintained by the Ministry of Environment of Taiwan (MOENV), allowing citizens to access information of environment at any time and receive activity recommendations based on real-time monitoring values.**

Keywords—Air Quality Monitoring Station, Air Quality Index (AQI), Air Quality Forecast, Artificial Intelligence (AI), Long-Short-Term Memory (LSTM), Spatial -Temporal Relations

I. INTRODUCTION

Air pollution is an issue about which people are highly concerned, and numerous studies have indicated that it can have adverse effects on human health [3]-[7]. As a result, governments worldwide are committed to monitoring air quality. Pollutants commonly monitored include $PM_{2.5}$, PM_{10}, O_3, CO, NO_2, and SO_2. These pollutants' concentrations are converted into an Air Quality Index (AQI) to reflect their impact on human health.

There is no specific standards for AQI, and Taiwan's MOENV employs a calculation approach that concentrations of pollutants converted into their corresponding sub-indicators based on their impacts on human health. The AQI is set to the value of the largest sub-indicator, and its corresponding item is the leading pollutant. The pollutants included in the calculation are O_3, $PM_{2.5}$, PM_{10}, CO, SO_2, and NO_2. Taiwan's MOEVN publishes two types of AQI: daily AQI and real-time AQI. This paper's focus is on the latter. Detailed calculation formulas can be found on the Taiwan Air Quality Monitoring Network [8].

The MOENV of Taiwan has established a total of 78 air quality monitoring stations and 10 mobile air quality monitoring stations. Apart from the pollutants referenced in the AQI, monitoring items include meteorological data such as wind speeds, wind directions, rainfall, humidity, and temperatures. The extensive and detailed monitoring data allows technologies like AI for prediction. Air quality prediction contributes to policy formulation and environmental management.

The objective of this paper is to develop an ANN model framework for predicting hourly real-time AQI for the coming 12 hours. This model framework is adapted for all 78 air quality monitoring stations in Taiwan to achieve the most prediction accuracy. LSTM layer was used to process feature of pollutants, weather, and time. LSTM is considered to be more effective than linear regression, decision trees, and various other deep learning models in air quality prediction [9]. For feature factors, pollutant concentrations, meteorological data, and time parameters were chosen. The training set involves target stations (the stations aimed to predict), neighboring stations, and outpost stations. Outpost stations refer to air quality monitoring stations along the northern border of Taiwan, which includes Kinmen, Matsu, Magong, and Wanli. The general variation in air quality is influenced by atmosphere. During this time, neighboring stations and target stations have a temporal relation. When long-range transport of air pollutants occurs, outpost stations and target stations also have a strong temporal correlation. Utilizing temporal relation to find a training data set is a commonly employed method that effectively enhances accuracy. This approach is called LSTM_ON (which means LSTM using Outpost stations and Nearby stations as a training set).

To verify the performance of the proposed approach, it was compared with the original solutions used by the Taiwan Air Quality Monitoring Network and the Environment Info Push app. This solution used linear regression and MLP (Multi-Layer Perceptron) repressor process feature factors, and the output of these two models was combined with meteorological data. The feature of combination was fed into the XGBoost model. Feature factors included pollutant concentrations and meteorological data, with only the target station as the training set. This approach was called XGB_NON (which means XGBoost layer No indicating Outpost stations and Neighboring stations). The verification results indicated that LSTM_ON and XGB_NON exhibited similar prediction errors for the next 1 hour (1.76 for the former, 1.63 for the latter). For the next 6 hours, LSTM_ON had a lower prediction error of 8.65 compared to XGB_NON's 12.11. For the next 12 hours, the prediction error was 13.4 for LSTM_ON and 18.59 for XGB_NON. LSTM_ON exhibited higher prediction accuracy than XGB_NON.

The MOENV of Taiwan has defined different levels of AQI: 0-50 is good, 51-100 is moderate, 101-150 is unhealthy for sensitive groups, 151-200 is unhealthy, 201-300 is very unhealthy, and 301-500 is hazardous. Accurately predicting the level at which AQI falls is crucial as different levels imply distinct governmental responses or activity recommendations

to the public. While such predictions are overall becoming easier, they are more practically useful for policy implementation references. Each prediction is statistically analyzed, and correctly predicting the level is considered successful. Based on the evaluation metric mentioned above, LSTM_ON achieved an accuracy of 86%. Subsequently, with the generation of new monitoring data, the training data was updated and the prediction model retrained. The accuracy for the next 1-4 hours increased from 93.9% to 94%, the next 5-8 hours increased from 86.4% to 86.9%, and the next 9-12 hours improved to 82.8%. There was an overall improvement in prediction accuracy. The approach proposed in this paper has been successfully applied to the Taiwan Air Quality Monitoring Network and the Environment Info Push app, which are on the official website of the MOENV of Taiwan.

The remainder of this paper is organized as follows. Section 2 discusses related tasks, and Section 3 illustrates the problem definition, objective, selection of model, reference stations, feature factor, and the model framework of the approach. Section 4 compares and analyzes experimental results of LSTM_ON and XGB_NON. Section 5 shows the implementation of the approach on the Taiwan Air Quality Monitoring Network and the Environment Info Push App. Section 6 summarizes this paper and discusses the future work.

II. Related Works

S. Sankar Ganesh et al. [19] attempted four different models and analyzed their performance. The first three methods employed the multiple regression model (MLR) in conjunction with various training algorithms such as batch gradient descent or steepest gradient descent, stochastic gradient descent, mini-batch gradient descent. The fourth approach utilized a support vector regression (SVR). The accuracy of MLR models can be enhanced by increasing the number of epochs, but it results in high computational complexity. In the earlier work, the MLR model was used for implementing the AQI prediction method. However, with the increasing researches, it has become evident that LSTM often outperformed MLR [9].

Li et al. [10] conducted a series of refinements on the performance of applying LSTM to air quality prediction. Data processing was divided into two parts. The first part involved historical $PM_{2.5}$ data, where a two-layer LSTM was employed to extract air quality features. The second part used meteorological data and time data (referred to as auxiliary data) as inputs, which underwent operations such as normalization and one-hot encoding. The outputs from the two aforementioned processes were merged, and a fully connected layer was used to perform feature extraction and generate the final prediction results. A limitation of this method is that it focuses solely on $PM_{2.5}$, which makes it insufficient for broader applications in air quality prediction.

Wang et al. [11] used Beijing as the research subject and employed image data format to describe monitoring data of air quality. They used cubic interpolation to fill in missing data in locations without monitoring stations. The monitoring data was treated as images and use CNN for spatial correlation feature extraction. A sequence-to-sequence structure with simplified attention was used to obtain air quality features. Finally, a fully connected layer was used for ANN to learn features and produce the result of prediction. This method only verified $PM_{2.5}$, PM_{10}, and O_3; it did not evaluate the AQI, which is an essential reference indicator for policy formulation and activity recommendations.

Soh et al. [12] based on their own research [13] foundation, proposed an improved method in three steps. The first step involved dynamic time warping (DTW) and Euler's formula to determine the closest temporal feature. The STR(Spatial-Temporal Relations) was used to extract air quality features. The second step involved TE(Terrain Extractor) to read features between neighboring terrains and air quality. The third step used LSTM to capture data from the target station for the preceding hours. Finally, the features from the three steps were concatenated, and a fully connected layer of ANN was used to learn features and produce the final prediction. This method has a comprehensive processing framework, addressing shortcomings from previous self-research, and considering both flat and undulating terrains. However, its overly complex decision mechanism could lead to implementation challenges and resource consumption.

Daniel Schürholz et al. [20] differed from the majority of studies that employed pollution and meteorological data for model training. They introduced a novel approach by merging aforementioned common data with context-aware computing, such as traffic information, fire alerts or events, and user characteristics. They built a model based on LSTM to integrate these diverse data sources. Furthermore, they established a real-world system, conducting experiments in Australia. This research employed distinctive data sources for feature analysis. This method demonstrates the potential for achieving high accuracy during specific events. However, the inclusion of various data sources can increase the complexity of data acquisition, and these specific events are not of a regular occurrence. Nevertheless, the utilization of data such as traffic information holds promise and warrants further exploration and investigation.

III. Methodology

A. Problem Definition

The objective of this paper is to enable all 78 fixed air quality monitoring stations in Taiwan to predict the AQI for the coming 12 hours, and to update these predictions with each latest hourly monitoring data. The construction and training of the model must satisfy both temporal and spatial correlations. Each air quality monitoring station has its own independent prediction model, as the reference data quantity for temporal relation varies for each station. The prediction model does not directly produce predicted AQI values, given the complexity of the AQI calculation process and the diverse nature of pollutants. The concentrations of four pollutants, including $PM_{2.5}$, PM_{10}, O_3 and NO_2 were individually forecast for the coming 12 hours, and the AQI was calculate based on these predictions. SO_2 and CO were excluded, as the probability of these two as leading pollutants is very low, and this helped conserve limited resources effectively. The process and architecture are shown in Figure 1. The entire functional module requires input from the previous 24 hours of monitoring data and produces predictions for the coming 12 hours' AQI on an hourly basis.

Next was selecting a suitable training model and input reference stations data that have temporal- spatial relations with the target station. Further details will be illustrated in the following section.

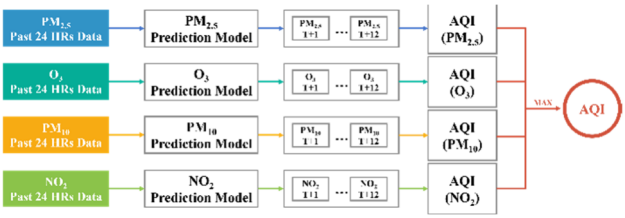


Fig. 1. The calculation steps for predicting AQI

B. *Selection of Model and Reference Stations*

The LSTM model was chosen in the ANN framework because it is applicable to classifying, processing, and predicting data based on time series [14] and has shown excellent results in many studies [9]. During the training of the model, data with high temporal -spatial relations must be considered. In general, selecting data from a nearby timeframe is a preliminary way to fulfill temporal-spatial correlations, which is a common approach in air quality prediction literature.

Another aspect worth delving into is the selection of reference stations, which contributes to meeting temporal relation. Nearby stations and outpost stations were picked as reference stations. Neighboring stations are those within a 20-kilometer radius of the target station, while outpost stations are a unique perspective proposed in this paper.

In Taiwan, the air quality is worse during the fall and winter seasons. Besides poor dispersion conditions in the south, another reason is that the northeast monsoon brings in pollutants from abroad, leading to poor air quality. In contrast, during the spring and summer seasons, the prevailing southwesterly winds lead to better dispersion conditions and fewer foreign pollutants, resulting in generally good air quality. Predicting good air quality during certain seasons is relatively easier compared to predicting it during seasons with poor air quality. Among the 78 monitoring stations, there are four located along the northern border: Kinmen, Matsu, Magong, and Wanli. They are the first to detect an increase in air pollutant concentrations when long-range transport of air pollutants occurs (as shown in Figure 2). Utilizing the aforementioned phenomenon of foreign pollution, data from these four outpost stations was incorporated into the training process, completing the crucial spatial correlation puzzle.

C. *Features and Architecture*

The selection of features includes pollutants such as CO, O_3, NO_2, NO_X, $PM_{2.5}$, PM_{10}, and SO_2, as well as meteorological data including humidity, wind speeds, wind directions, and temperatures. The incorporation of meteorological data is mainly due to the close relationship between overall environmental air quality variations and climate conditions, which is also a factor commonly considered in most research papers. To enhance the training consequent and account for the continuity and periodicity of time, the hours and days of the prediction time were transformed using trigonometric functions. Using trigonometric functions, it could project one-dimensional features into a two-dimensional space. This can effectively address temporal continuity in features, such as the transition from 11 PM to 1 AM or from December 31st to January 1st, which actually represent continuous time periods. Similarly, wind direction poses a similar challenge, as the difference between 360 degrees and 1 degree also exhibits continuity. Directly inputting these features into a model can lead to suboptimal training results. The schematic representation of trigonometric function transformations is illustrated in Figure 3.The pollutant concentrations of the target station itself and climate data were both included as feature factors for training. However, the neighboring stations and outpost stations primarily served the purpose of assessing atmospheric changes. For these stations, only wind speeds, wind directions, and predicted pollutant concentrations were included as input data to observe variations in the atmospheric environment and pollutant concentrations.

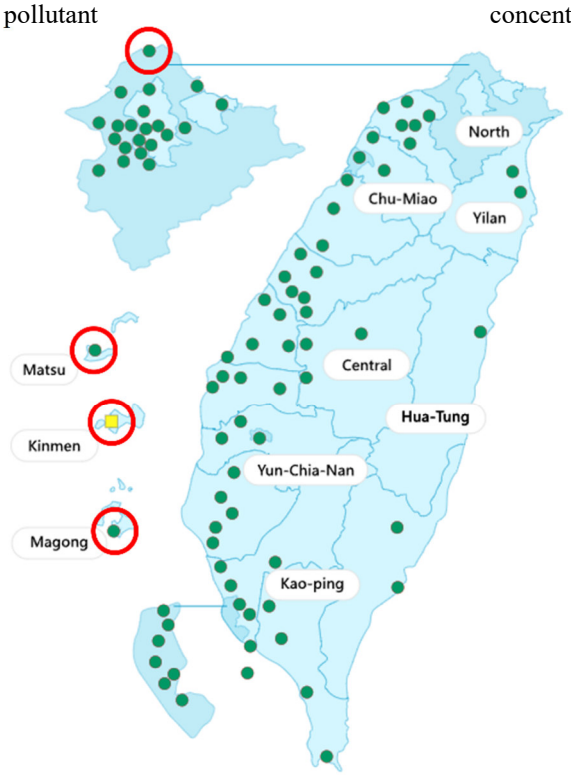


Fig. 2. Station’s location map(Outpost stations are marked with red circles)

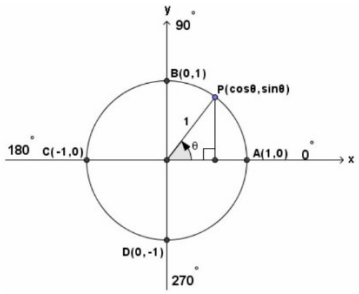


Fig. 3. Schematic representation of trigonometric function transformations

In summary, the input layer of the neural network architecture in this paper includes all pollutants and meteorological data from the target stations. The reference stations contribute wind speeds, wind directions, and the concentrations of the target pollutants as input data. Additionally, the prediction time is included as input data. Historical feature data underwent transformation using LSTM layers, while time data was transformed using fully connected layers. The resulting data was then combined and processed through three fully connected layers to output hourly predictions for the coming12 hours of the target pollutants. The construction of the neural network model is illustrated in Figure 4.

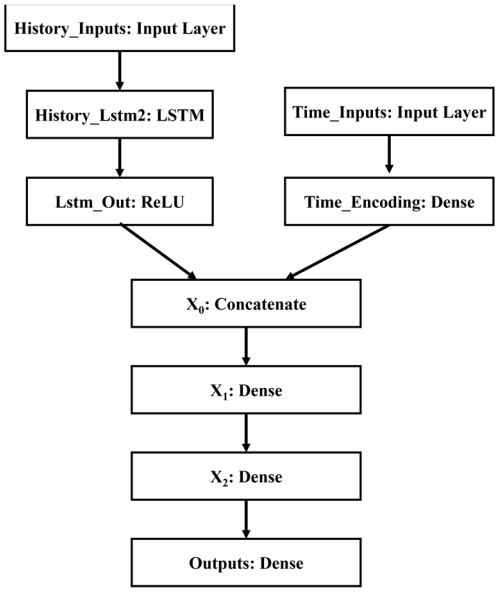


Fig. 4. Architecture of LSTM_ON

The model automatically tunes its parameters through a Grid Search process, continuously modifying numerical values, and retraining the model until all parameter combinations have been executed. This process is considered complete when all possible parameter combinations have been evaluated. This procedure can be time-consuming but is essential for identifying the optimal model parameter settings. The final parameters and hyperparameters set in this paper are as follows. In the historical data processing section, the first hidden layer, which is the LSTM layer, is configured with 64 units. The second hidden layer utilizes the ReLU activation function. In the time data processing section, a Dense layer with 16 units is used for feature extraction. After data transformation and merging, there are two Dense hidden layers, each with 128 units. The activation function is set to ReLU as well. The optimizer is SGD with a learning rate of 0.01, and the clip value is set to 1. During the training process, the number of epochs is 25, and the batch size is set to 32.

IV. Experiment and Analysis

A. Data Set

Data from the official open data website of the Taiwan MOENV [15] was utilized, which provides hourly updates on monitoring data from 78 fixed air quality monitoring stations. This data is now also available on Kaggle [16], including measurements for $PM_{2.5}$, PM_{10}, O_3, NO_X, CO, NO_2, and SO_2, as well as various meteorological measurements such as wind speeds, wind directions, humidity, and temperatures.

When predicting all four target pollutants, this model utilized the nearly 24 hours of monitoring data. It performed numerical transformations on these data, using mathematical operations such as square root or logarithmic transformations to make the values approach a normal distribution. This was done to reduce the impact of outliers. A total of nine important features were used, and each feature played an important role in predicting the outcomes. The monitoring data that undergo square root transformation included: CO, NO_2. logarithmic transformations included PM_{10}, SO_2, rainfall, $PM_{2.5}$. The impact of applying this method on the data distribution is as shown in the Figure 5 and Figure 6.

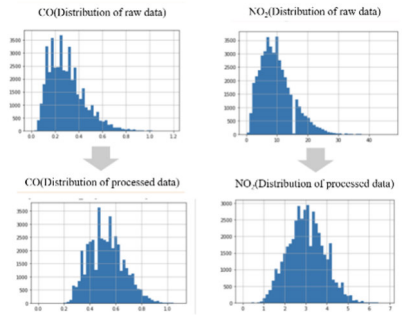


Fig. 5. Destribution of raw data and processed data(CO and NO_2)

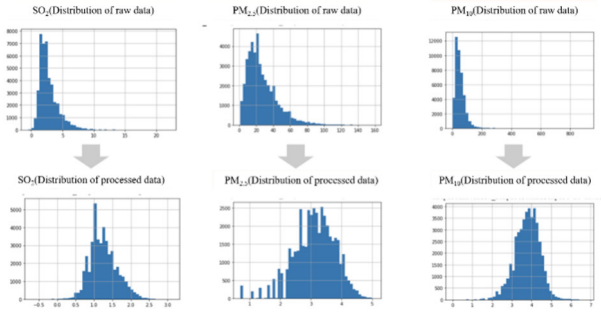


Fig. 6. Destribution of raw data and processed data(SO_2, PM2.5 and PM_{10})

The validation of LSTM_ON and XGB_NON was conducted using monitoring data from 2018-2019, with validation carried out using data from the year 2020. Subsequently, in response to the generation of new yearly monitoring data, the LSTM_ON model was retrained using data from 2019-2020, and it was validated with data from 2021.

B. XGB_NON

This method represents the predictive approach originally used by the Taiwan Air Quality Monitoring Network and the Environment Info Push app. Its input layer includes pollutant concentrations and meteorological data (i.e., the feature factors of this method). Linear regression and MLP regressor were used to compute pollutant data, and the output results were combined with meteorological data. The concatenated data from both sources was then input to the XGBoost model for training. This method did not incorporate data from neighboring or outpost stations as feature factors. The neural model architecture of XGB_NON is illustrated in Figure 7.

C. Metric

Two methods to measure performance were used: the first is the average prediction error, and the second is the accuracy of AQI levels. The calculation of the average error involves the absolute difference between the predicted values and the actual measured values, divided by the total number of predictions, resulting in the mean absolute error (MAE). The mathematical expression is as follows,

$$P = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n} \quad (1)$$

where P is the metric, y_i and x_i are the prediction and ground truth for the next i_{th} hour, respectively, and n is the number prediction with a time interval.

Each point in time i predicted a total of 12 times. The first prediction represents the value for the coming 12 hours, the

second prediction is for the coming 11 hours, and the final prediction is for the next 1 hour. The predictions for each hour from 1 to 12 were separated and analyzed, observing the prediction results for different forecast horizons.

The MOENV of Taiwan references practices from various countries to classify AQI value based on the degree of impact on human health. It is divided into six levels: good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy, and hazardous. Different levels are shown by different colors, and this rule is applied in both the Taiwan Air Quality Monitoring Network and the Environment Info Push app.

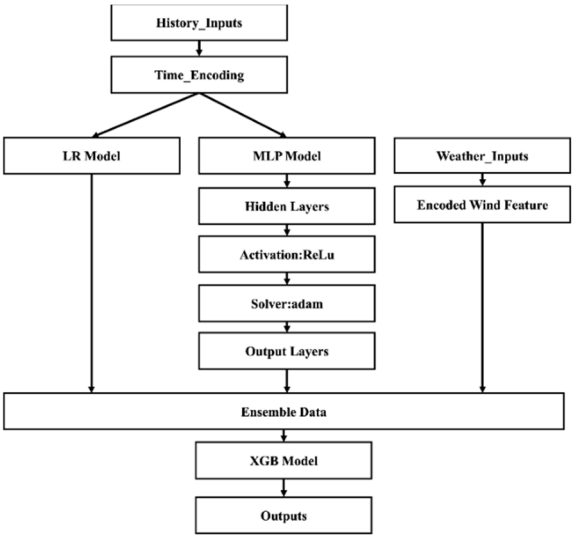


Fig. 7. Architecture of XGB_NON

D. Performance

The predictions of LSTM_ON and XGB_NON trained with the 2018-2019 monitoring data, were compared for January 2020 (considered a period of poor air quality and a challenging forecasting month). Apart from a slight loss in LSTM_ON's 1-hour prediction with 1.76 compared to XGB_NON's 1.63, LSTM_ON outperformed XGB_NON in the remaining forecast periods. Of particular interest were the next 6-hour and 12-hour predictions, where LSTM_ON achieved 8.65 and 13.41, respectively, while XGB_NON achieved 12.11 and 18.59. Detailed MAE of hourly predictions as shown in Figure 8. The experimental results indicate that LSTM_ON achieved better performance in longer forecast periods, which provides significant benefits for environmental management and control.

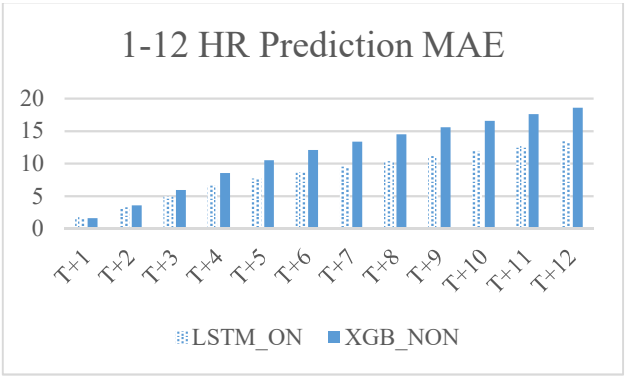


Fig. 8. AME of LSTM_ON and XGB_NON

LSTM_ON was evaluated using Level accuracy. For the period from January to September 2020, the prediction accuracy of LSTM_ON for the upcoming 1-4 hours was around 90% for all monitoring stations. Accuracy was above 80% for the months of May to August, and above 70% for the remaining months. Overall, the average level accuracy of LSTM_ON was 86%. Detailed level accuracy of hourly predictions are shown in Figure 9.

With the emergence of new monitoring data and changes in atmospheric conditions, the existing training data becomes insufficient to represent and predict the new environmental data accurately. When comparing the LSTM_ON model trained on data from 2019-2020 with the previous version of LSTM_ON, the prediction accuracy for the upcoming 1-4 hours at all monitoring stations during the period from March to June 2021 was 94% and 93.9%, respectively. For the coming 5-8 hours, the accuracy was 86.9% and 86.4%, and for the coming 9-12 hours, the accuracy was 82.8% and 80.9%, respectively. All of these values show a slight improvement. Detailed results of hourly predictions are shown in Figure 10.

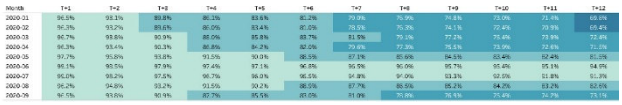
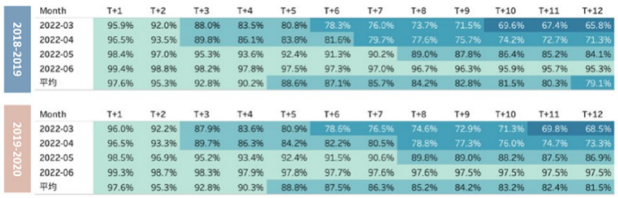


Fig. 9. Level accuracy of LSTM_ON from January to September 2020



2018-2019	Month	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9	T+10	T+11	T+12
	2022-03	95.9%	92.0%	88.0%	83.5%	80.8%	78.3%	76.0%	73.7%	71.5%	69.6%	67.4%	65.8%
	2022-04	96.5%	93.5%	89.8%	86.1%	83.8%	81.6%	79.7%	77.6%	75.7%	74.2%	72.7%	71.3%
	2022-05	98.4%	97.0%	95.3%	93.6%	92.4%	91.3%	90.2%	89.0%	87.8%	86.4%	85.2%	84.1%
	2022-06	99.4%	98.8%	98.2%	97.8%	97.5%	97.3%	97.0%	96.7%	96.3%	95.9%	95.7%	95.3%
	平均	97.6%	95.3%	92.8%	90.2%	88.6%	87.1%	85.7%	84.2%	82.8%	81.5%	80.3%	79.1%

2019-2020	Month	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9	T+10	T+11	T+12
	2022-03	96.0%	92.2%	87.9%	83.6%	80.9%	78.6%	76.5%	74.6%	72.9%	71.3%	69.8%	68.5%
	2022-04	96.5%	93.3%	89.7%	86.3%	84.2%	82.2%	80.5%	78.8%	77.3%	76.0%	74.7%	73.3%
	2022-05	98.5%	96.9%	95.2%	93.4%	92.4%	91.5%	90.6%	89.8%	89.0%	88.2%	87.5%	86.9%
	2022-06	99.3%	98.7%	98.3%	97.9%	97.8%	97.7%	97.6%	97.6%	97.5%	97.5%	97.5%	97.5%
	平均	97.6%	95.3%	92.8%	90.3%	88.8%	87.5%	86.3%	85.2%	84.2%	83.2%	82.4%	81.5%

Fig. 10. LSTM_ON with different training data of time periods

V. Application of Public Service

The proposed predictive method is also showcased in the Taiwan Air Quality Monitoring Network and the Environment Info Push app maintained by the MOENV of Taiwan. All 78 air quality monitoring stations provide hourly AQI predictions for the coming 12 hours, as depicted in Figure 11 and Figure 12. The Environment Info Push app not only displays the most recent hour's observation data for each station but also presents the past 12-hour AQI trend as solid lines and the predicted AQI for the coming 12 hours as dashed lines. Additionally, various activity recommendations for the public are provided below the display. By utilizing the predictive model proposed in this paper, the Taiwan Air Quality Monitoring Network and the Environment Info Push app generate reliable prediction results, providing the public with valuable guidance for outdoor activities.

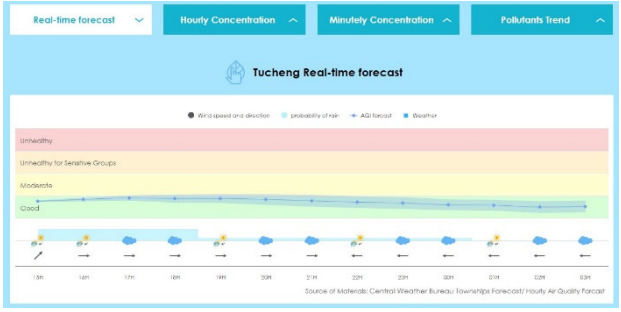


Fig. 11. Prediction result in Taiwan Air Quality Monitoring Network

VI. Conclusion and Future Work

This paper presents a neural network model constructed by using LSTM, utilizing the pollution data from the target stations along with the target pollutants and meteorological data from neighboring and outpost stations as feature factors for model training. The model employs nearly 24 hours of monitoring data to predict hourly AQI for the coming 12 hours. The model was evaluated by using Mean Absolute Error (MAE) which is a measure of errors between paired observations expressing the identical phenomenon and level accuracy, comparing it with the original XGB_NON approach, and improved accuracy was observed across both metrics. By incorporating training with outpost stations specific to Taiwan's environmental conditions, the model captures the influence of long-range transport of air pollutants, enabling early identification of days with poor air quality. This allows both government authorities and the public to respond promptly. In the future, the aim is to integrate meteorological forecast data to enhance predictions and extend the forecast horizon, enabling stakeholders to take precautionary measures even earlier. Two types of data will be used in the future. The first is meteorological forecast data, which can assist in predicting air quality. The Central Weather Bureau of Taiwan (CWB of Taiwan) has rich experience and advanced tools in meteorological forecasts. The second is microsensors. The MOENV has installed more than 10,000 air quality micro-sensors throughout Taiwan since 2016 [18], covering various locations. More detailed data can help improve the accuracy of predictions. In addition, many studies aim to predict air quality for the coming 48 hours. The future goal is to improve the prediction length and obtain reliable results so that relevant personnel can take measures earlier.

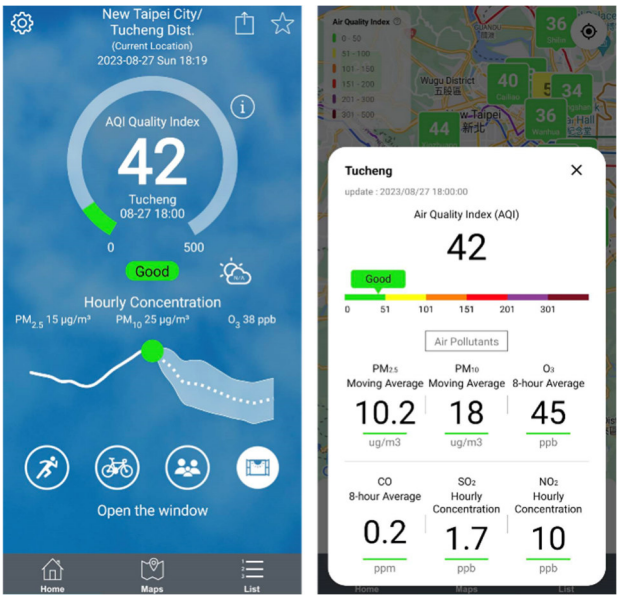


Fig. 12. Dashboard of Environment Info Push App

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附錄 3、會議資料

2023 33rd International Telecommunication Networks and Applications Conference (ITNAC)

Time	Room 1	Room 2	Welcome
Tuesday, November 28			
16:00-18:00			WR: ***Welcome Reception***
Wednesday, November 29			
08:00-08:30	R1: ***Registration***		
08:30-10:30	S1: ***Session 1: Mobile***	S2: ***Session 2: Wireless***	
10:30-11:00	MT1: ***Morning Tea***		
11:00-12:00	K1: ***Opening Keynote - Dealing with Spatial and Temporal Complexities in Cyber-Physical Systems: Simple solutions for complex problems***		
12:00-12:45	K2: ***Keynote - Neoteric Frontiers in Cloud, Edge, and Quantum Computing***		
12:45-13:30	L1: ***Lunch***		
13:30-15:30	S3: ***Session 3: General***	S4: ***Session 4: Networks***	
15:30-16:00	AT1: ***Afternoon Tea***		
16:00-18:00	S5: ***Session 5: IoT and wireless***	S6: ***Session 6: Networking and General***	
Thursday, November 30			
08:30-10:30	S7: ***Session 7: Optical networking***	S8: ***Session 8: IoT***	
10:30-11:00	MT2: ***Morning Tea***		
11:00-11:45	K3: ***Keynote - Automation and Orchestration of 5G Network Slices across RAN, Core, and Transport domains in the context of 5G Network Slicing***		

11:45-12:30	L2: ***Lunch***		
12:30-16:30	T1: ***Conference Tour***		
16:30-18:00		W2: ***Workshop 2: 5G Labkit Demonstration***	
18:00-22:00	D1: ***Conference Dinner***		

Friday, December 1

08:30-10:30	S9: ***Session 9: IoT and General***	S10: ***Session 10: Networks and Security***	
10:30-11:00	MT3: ***Morning Tea***		
11:00-12:00	K4: ***Keynote - Addressing Data Leakage in Split Learning: Attacks and Defence Strategies***		
12:00-13:00	L3: ***Lunch***		
13:00-15:00	S11: ***Session 11: Networks and Design***	S12: ***Session 12: Wireless and Security***	
15:00-15:30	AT3: ***Afternoon Tea***		
15:30-15:40	CR: ***Closing Remarks***		

Tuesday, November 28

Tuesday, November 28 16:00 - 18:00 (Australia/Melbourne)

WR: Welcome Reception

Shuo Li

Room: Welcome

Venue: Building 10, Level 7, Room 52 Portal (it is the open area)

Wednesday, November 29

Wednesday, November 29 8:00 - 8:30 (Australia/Melbourne)

R1: Registration

Venue: Level 7 Building 16 Green Brain, Swanston St

Wednesday, November 29 8:30 - 10:30 (Australia/Melbourne)

S1: Session 1: Mobile

Room 1

Chair: Leith H. Campbell (RMIT University, Australia)

8:30 ***Energy Efficient Data Collection Using Predefined Path Constrained Mobility for Mobile Sinks in Wireless Sensor Networks*** ☐ ☐

Mohammed F Suleiman (Teesside University, United Kingdom (Great Britain)); Usman Adeel (Teesside University & Intel UK, United Kingdom (Great Britain))

Recently, the utilization of mobile sinks (MSs) has gained significant attention in wireless sensor networks (WSNs) research due to its potential for improving network lifetime compared to traditional static sinks. However, mobility in WSNs still presents challenges such as node failures in random mobility techniques and high computational and processing resources required in predicted mobility approaches, which can impact long-term stability and network lifetime. In this study, we propose a Predefined Path Constrained Mobility (PPCM) routing protocol utilizing multiple sinks stationed at different areas of the network. These sinks move in a fixed pattern to collect data from sensor nodes. Through evaluation, we demonstrate that the PPCM protocol outperforms existing routing protocols such as Random Multiple Mobile Sink (RMMS) and Multiple Random Mobile Sink Confined (MRMS-C) protocols in terms of overall network lifetime. The proposed protocol offers a potential solution to address routing challenges in WSNs with the use of mobile sinks.

pp. 1-6

8:54 ***Exploring Cellular Communications for Remote Offshore Aquaculture Monitoring*** ☐ ☐

Johannus Kristmundsson (University of the Faroe Islands, Faroe Islands); Øystein Patursson (RAO, Faroe Islands); John R Potter (NTNU, Norway); Qin Xin (University of the Faroe Islands, Faroe Islands)

In the evolving landscape of aquaculture, remote offshore fish farms present unique challenges and opportunities. This paper investigates the potential of harnessing cellular communications, with a particular emphasis on 5G, to enhance connectivity in these distant marine environments. Through link budget analysis, we evaluate the channel conditions over the vast distances that remote offshore fish farms require. The research sheds light on how various environmental factors impact signal strength and highlights the transformative role of machine learning in streamlining farm operation data, paving the way for efficient real-time monitoring. The findings underscore the potential of cellular communications in advancing offshore aquaculture monitoring, ensuring efficient data transmission, and fostering sustainable marine farming practices.

pp. 7-10

9:18 ***Mutual Authentication between Aerial Base Stations and Core Network: A Lightweight Security Scheme*** ☐ ☐

Kai-Chun Yang and Po-Ching Lin (National Chung Cheng University, Taiwan)

The 3rd Generation Partnership Project (3GPP) is actively working on incorporating non-terrestrial networks (NTNs) into the 5G system. NTNs integrate various aerial and space components like uncrewed aerial vehicles (UAVs), airships, and satellites to offer flexible solutions for extending the ground systems. In the context of aerial radio access networks (ARANs), aerial base stations (ABSs) are deployed in clusters. However, due to the dynamic nature of ABSs, additional identity authentication is required between user equipment (UE), core network (CN), and ABSs. It is crucial to design lightweight authentication protocols that are subject to the limited computing resources and energy constraints of UAVs. We observe that aerial facilities possess multiple attributes, which can be leveraged to integrate identity authentication of the involved entities based on specific attribute sets. This study proposes an attribute-based authentication and key agreement protocol for ABSs and the CN, utilizing ciphertext-policy attribute-based encryption (CP-ABE). This approach enables access control based on physical attributes, ensuring secure communication and identity authentication in the ARANs. The protocol reduces the need for repeated execution of the authentication and key agreement (AKA) protocols between UE and the CN during ABS replacement. It employs elliptic curve cryptography (ECC) and fixed-length keys to minimize computational overhead during decryption, and also supports mutual authentication between ABSs during UE handover. The design aligns with the 3GPP specifications, aiming for practical field application in the future.

pp. 11-18

9:42 ***A New Class of Optimal Frequency Hopping Sequences with Applications to Secure Communication Waveforms*** ☐ ☐

Krishnasamy T Arasu, Michael Clark and Timothy McManus (Riverside Research, USA)

Frequency hopping (FH) is a spread spectrum technique used to protect against detection, interception, location, and jamming where the transmission frequency is changed in a seemingly random manner, only occupying a given frequency band for a very short amount of time. FH systems provide low probability of intercept (LPI) capabilities mainly by using large hop bandwidths. Using large portions of the electromagnetic spectrum is beneficial because it makes it potentially more difficult for a third party to monitor the entire bandwidth at once. A popular way to implement FH is by using specially designed pseudorandom sequences known only to the intended users. The pseudorandom sequences must be designed according to certain mathematical properties in order to guarantee that an attacker cannot easily learn the hopping sequence and defeat the protection. Prior research has revealed an interesting equivalence relation between mathematically optimal FH sequences and partitioned difference families in cyclic groups. Using this relationship, we provide a method that yields new families of optimal FH sequences, inequivalent to known ones. The resulting FH sequence families contain several members whose underlying pseudorandom sequences possess high linear span, thereby making them desirable for secure communications. Our research shows exponential growth of the linear span, which is a significant increase in security over the state of the art (SOA).

pp. 19-24

10:06 ***URLLC in B5G Networks: Use cases, TSN/DetNet extension, and Pending issues*** ☐ ☐

Aiman Nait abbou (Aalto University, Finland); Konstantinos Samdanis (Lenovo, Germany); Jukka M J Manner (Aalto University, Finland)

Originally, 5th Generation (5G) mobile networks were expected to carry the demands of the Internet of Everything (IoE) and Ultra-Reliable and Low-Latency Communications (URLLC) services. However, state-of-the-art of wireless mobile technologies failed to meet these expectations. Beyond 5G (BG5) wireless networks have the potential to leverage the benefits of a mature transported network, and enhanced capabilities related to high reliability and extremely low End-to-End Latency. This paper investigates the potential of B5G with extreme URLLC use cases. It also provides an overview and vision of the potential integration of B5G with Time-Sensitive Networking (TSN) for indoor scenarios, and Deterministic Networking (DetNet) with Segment Routing (SR) for outdoor scenarios.

pp. 25-30

Wednesday, November 29 8:30 - 10:30 (Australia/Melbourne)

S2: Session 2: Wireless

Room 2

Chair: Mohammad Hasan (UKM, Malaysia)

8:30 ***Modeling and Evaluation of Geophone Energy Consumption in Wireless Seismic Data Acquisition Networks*** ☐ ☐

Aliyu Makama (Hamburg University of Technology, Germany); Koojana Kuladinithi (Hamburg University of Technology & Institute of Communication Networks, Germany); Andreas Timm-Giel (Hamburg University of Technology, Germany)

Impediments associated with cable-based seismic data acquisition (SDA) have led to increased interest in enabling reliable wireless seismic data acquisition (WSDA)systems. As the SDA process can last for several days or weeks, it is imperative to ensure geophones remain active for extended data acquisition periods without frequent recharging or battery replacements. This paper presents an evaluation of geophone energy consumption based on a proposed IEEE 802.11-based WSDA network architecture operating in ad hoc mode that employs Routing Protocol for Low-Power and Lossy Networks (RPL). The evaluation was carried out using simulation in OMNeT++ simulator employing metrics like percentage energy consumed and network lifetime. Results show that geophones can operate continuously for up to a month, with energy consumption primarily influenced by geophone hardware specifications, especially the radio or transceiver unit and battery capacity. In addition, we present an analytical model that estimates geophone energy consumption based on the proposed architecture. The model is an extension of our proposed IEEE 802.11 Distributed Coordination Function (DCF) model, incorporating geophone radio hardware specifications. The model was validated using simulations in the OMNeT++ simulator.

pp. 31-37

8:54 ***Feasibility Study on Position Verification in Urban UAV Networks*** ☐ ☐

Konrad Fuger (Hamburg University of Technology, Germany); Koojana Kuladinithi (Hamburg University of Technology & Institute of Communication Networks, Germany); Manav Sood and

Andreas Timm-Giel (Hamburg University of Technology, Germany)

Unmanned Aerial Vehicles (UAVs) hold transformative potential across industries like delivery, surveillance, and maintenance. In urban settings, ensuring safe UAV operations demands position exchange to prevent collisions and monitor the airspace. This poses the problem that malicious UAV operators could falsify their announced position. Our study evaluates four mechanisms to detect falsified positions, differentiating between autonomous and cooperative approaches. We present a theoretical analysis highlighting the strengths and limitations of these mechanisms, alongside comprehensive simulations. Our results show that the best-performing mechanism needs less than 1s to detect all malicious nodes present. In addition, this mechanism can detect more than 98% of falsified packets given a sufficient difference between real and claimed position. Further, we show that the cooperative mechanisms produce a data overhead of less than 30%. Our work demonstrates the feasibility of position verification for urban UAV networks.

pp. 38-43

9:18 ***DANCE: Dynamic Anchor Node-based Cooperative Enhancement of Wireless Indoor Localization for Internet of Things*** ☐ ☐

Jin-Min Lee (Sungshin Women's University, Korea (South)); Na-Yeon Shin and Jung-Hyun Moon (Sungshin University, Korea (South)); Il-Gu Lee (Sungshin Women's University, Korea (South))

With the recent widespread use of ultra-high-speed, ultra-low-latency wireless sensor network applications, the demand for location-based services in wireless indoor environments is increasing. In addition, wireless sensors are used to improve industrial productivity and safety using cyberphysical system automatic control technology. However, wireless sensor devices have limited computing power and battery capacity, making frequent trilateration operations or complex machine learning-based operations challenging. Therefore, this study proposes a dynamic anchor node-based cooperative enhancement (DANCE) technique that improves accuracy and reduces computation costs compared to the conventional trilateration method. The proposed DANCE technique improves localization efficiency and accuracy by adjusting the number of anchor nodes used for localization according to the node's speed. Experimental results demonstrated that when the fading index was 1 in Nakagami-m fading and the node to be localized was at an average speed of 1-5 m/s, the error rate decreased by at least 24.5% compared to the conventional method, and the computation cost was reduced by at least 8.4% compared to the conventional method.

pp. 44-50

9:42 ***Adaptive compression of operational commands for remote network management over LPWA*** ☐

Kodai Tanabe and Go Hasegawa (Tohoku University, Japan); Gen Kitagata (Morioka University, Japan)

When LPWA can be employed as a management network in out-of-band management of network equipment, the advantages of the low power consumption and long communication distance of LPWA allow for low-cost operation. However, the small datarate of LPWA degrades the performance of remote management. Therefore, in our work, we aim to improve the effective datarate of LPWA by applying highly efficient compression using command history. We introduce a command tree to efficiently maintain the appearance frequency of the command and codes for encoding. We employ Huffman coding-based compression method, exploiting the biases of used commands. In the proposed method, we dynamically construct the command tree according to the command input from the administrator, which allow the proposed method to be applied to various network equipment regardless of its command grammar. Through experimental evaluation, we show that the compression ratio is up to 3.5%, which is significantly better than the traditional compression method, while it has enough small memory usage and computation overhead. Also, the proposed method can provide 10 kbps for the effective datarate with LPWA, which is almost equivalent to standard datarate for management using serial communication.

pp. 51-56

10:06 ***Detection of Crucial Power Side Channel Data Leakage in Neural Networks*** ☐ ☐

Amjed Ahmed (Imam Kadhim (A) for Isalmic Science University, Iraq); Mohammad Hasan (UKM, Malaysia); Nurhizam Safie Mohd Satar (The National University of Malaysia (UKM), Malaysia); Nazmus Shaker Nafi (Kellogg Brown and Root, Australia); Azana Hafizah Mohd Aman (Universiti Kebangsaan Malaysia, Malaysia); Shayla Islam (UCSI University, Malaysia); Saif Aamer Fadhil (Imam Al Kadhum College IKC, Iraq)

Neural network (NN) accelerators are now extensively utilized in a range of applications that need a high degree of security, such as driverless cars, NLP, and image recognition. Due to privacy issues and the high cost, hardware implementations contained within NN Propagators were often not accessible for general populace. Additionally with power and time data, accelerators also disclose critical data by electro-magnetic (EM) sided channels. Within this study, we demonstrate a side-channel information-based attack that can successfully steal models from large-scale NN accelerators deployed on real-world hardware. The use of these accelerators is widespread. The proposed method of attack consists of two distinct phases: 1) Using EM side-channel data to estimate networking's underlying architecture; 2) Using margin-dependent, attackers learning actively in estimating parameters, notably weights. Deducing the underlying network structure from EM sidechannel data. Inferring the underlying network structure from EM sidechannel data. Experimental findings demonstrate that the disclosed attack technique can be used to precisely retrieve the large-scale NN via the use of EM side-channel information leaking. Overall, our attack shows how critical it is to conceal electromagnetic (EM) traces for massive NN accelerators in practical settings.

pp. 57-62

Wednesday, November 29 10:30 - 11:00 (Australia/Melbourne)

MT1: Morning Tea

Mark Gregory

Venue: Level 6 Building 16 Green Brain, Swanston St

Wednesday, November 29 11:00 - 12:00 (Australia/Melbourne)

K1: Opening Keynote - Dealing with Spatial and Temporal Complexities in Cyber-Physical Systems: Simple solutions for complex problems

Professor Xinghuo Yu, RMIT University

Room 1

Chair: Mark A. Gregory (RMIT University, Australia)

The fast advances in information and communication technologies have made it possible to enable ambient data intelligence and situational awareness in large-scale Cyber-Physical Systems such as smart grids, logistic networks, and transportation, for optimal, reliable operations and management. However, it has also led to explosive growth of spatial and temporal information and computational complexity. An innovative way of thinking is required to tackle these large-scale complex network problems efficiently and effectively. In this talk, we advocate a novel problem-solving approach, which embraces a philosophy of 'simple solutions for

complex problems', to deal with the spatial and temporal complexities in order to deliver just-enough just-in-time reliable solutions. Key to the successful problem solving by this approach is to balance problem simplification and solution accuracy. Well known nature-inspired methodologies such as AI, machine learning, neural networks, swarm intelligence, complex networks, will be examined. Several real-world problems we have tackled, such as money laundering network detection, spectrum occupancy prediction in wireless communications, autonomous microgrid networks, etc, will be used as case studies to inform the discussions.

Wednesday, November 29 12:00 - 12:45 (Australia/Melbourne)

K2: Keynote - Neoteric Frontiers in Cloud, Edge, and Quantum Computing

Professor Rajkumar Buyya, University of Melbourne, IEEE Fellow

Room 1

Chair: Mark A. Gregory (RMIT University, Australia)

Computing is being transformed to a model consisting of services that are delivered in a manner similar to utilities such as water, electricity, gas, and telephony. In such a model, users access services based on their requirements without regard to where the services are hosted or how they are delivered. Cloud computing paradigm has turned this vision of "computing utilities" into a reality. It offers infrastructure, platform, and software as services, which are made available to consumers as subscription-oriented services. Cloud application platforms need to offer (1) APIs and tools for rapid creation of elastic applications and (2) a runtime system for deployment of applications on geographically distributed Data Centre infrastructures (with Quantum computing nodes) in a seamless manner. The Internet of Things (IoT) paradigm enables seamless integration of cyber-and-physical worlds and opening opportunities for creating new class of applications for domains such as smart cities, smart robotics, and smart healthcare. The emerging Fog/Edge computing paradigms support latency sensitive/real-time IoT applications with a seamless integration of network-wide resources all the way from edge to the Cloud. This keynote presentation will cover (a) 21st century vision of computing and identifies various IT paradigms promising to deliver the vision of computing utilities; (b) innovative architecture for creating elastic Clouds integrating edge resources and managed Clouds, (c) Aneka 5G, a Cloud Application Platform, for rapid development of Cloud/Big Data applications and their deployment on private/public Clouds with resource provisioning driven by SLAs, (d) a novel FogBus software framework with Blockchain-based data-integrity management for facilitating end-to-end IoTFog/Edge-Cloud integration for execution of sensitive IoT applications, (e) experimental results on deploying Cloud and Big Data/ IoT applications in engineering, and health care (e.g., COVID19), deep learning/Artificial intelligence (AI), satellite image processing, and natural language processing (mining COVID-19 research literature for new insights) on elastic Clouds, (f) QFaaS: A Serverless Function-as-a-Service Framework for Quantum Computing, and (g) directions for delivering our 21st century vision along with pathways for future research in Cloud and Edge/Fog computing.

Wednesday, November 29 12:45 - 13:30 (Australia/Melbourne)

L1: Lunch

Venue: Level 6 Building 16 Green Brain, Swanston St

Wednesday, November 29 13:30 - 15:30 (Australia/Melbourne)

S3: Session 3: General

Room 1

Chair: Mohammad Hasan (UKM, Malaysia)

13:30 ***Digital Twin Migration using the OKD platform: A Use-Case for Emergency Vehicles*** ☐ ☐

Bruno Ribeiro (University of Aveiro, Portugal); Pedro A. Gonçalves (Universidade de Aveiro, Portugal); Paulo C. Bartolomeu (University of Aveiro, Portugal)

The compute capabilities in modern vehicles are on the rise, resulting in increasingly advanced driving assist features accompanied by increased vehicle costs. To reduce cost while providing similar assistance features, research in autonomous vehicles has focused on cooperative scenarios where mobile entities with sensing capabilities share their knowledge and are supported by the roadside infrastructure that provides computing, storage and network resources.

We present a use case for container migration on edge networks to reduce application downtime concerning autonomous emergency response vehicles and their coordination in the field. To provide lower communication delay and faster access to data, the digital twins of the vehicles are implemented as containers placed at network edge nodes.

By measuring the time necessary to perform a complete migration of a running container to a different edge node, while keeping its execution state, we attained the goal of keeping application downtime low through container migration and identifying possible improvements to the system.

pp. 63-69

14:00 ***CaliProb: Probability-based Calibration Model for Robust Predictions in Environments with Data Biases*** ☐ ☐

Yu-Ran Jeon (Sungshin Women's University, Korea (South)); Jung-Hwa Ryu (Seoul, Korea (South)); So-Yeon Kim (Sungshin Women's University, Korea (South)); Na-Eun Park (Seoul, Korea (South)); Il-Gu Lee (Sungshin Women's University, Korea (South))

Various studies have focused on solving data bias problems in artificial intelligence. However, conventional approaches have primarily focused on data biases originating from imbalanced data distributions between sensor nodes and algorithms owing to overfitting. However, methods handling the biases between sensors have rarely been considered. In general, when data are trained using multiple heterogeneous devices, a device bias occurs due to process, voltage, and temperature variations, differences in the preprocessing methods for each device and the aging of specific devices, resulting in a data bias. In this study, we prove that a data bias can occur due to a device bias, which deteriorates the training performance. In response, we propose the probability-based calibration (CaliProb) model. This model compares the predicted probabilities for each piece of data, selects the data with the best training performance as the reference data, and calibrates the data bias using these reference data. We experimentally verify the CaliProb model. It exhibits an accuracy greater than that of the uncalibrated general model in situations with low and high data biases and achieves an accuracy that is approximately 12.2% higher than that of the Non-calibrated model in a case with abundant data bias.

pp. 70-75

14:30 ***Spreading Sequence Blind Estimation in DSSS System Using Gradient Ascent Method*** ☐ ☐

Yooncheol Choi, Dongyeong Kim, Mingyu Jang and Dongweon Yoon (Hanyang University, Korea (South))

In direct sequence spread spectrum systems, a receiver must know the spreading code to despread a signal. In non-cooperative contexts, there is no prior information about the spreading code, and it must be blindly estimated. Generally, the maximum likelihood-based method is known to show optimal performance in terms of estimation accuracy, but its computational complexity hinders its practicality. In this paper, we propose an estimation algorithm for the spreading sequence that reduces the computational complexity of the maximum likelihood-based algorithm by applying the gradient ascent method. To validate the proposed method, we compare the estimation performance of the proposed algorithm with that of an existing method in terms of their computational complexity and the error rate of a chip in the estimated spreading sequence.

pp. 76-79

15:00 ***Optimization Technique for Deep Learning Methodology on Power Side Channel Attacks*** ☐ ☐

Amjed Ahmed (Imam Kadhim (A) for Isalmic Science University, Iraq); Mohammad Hasan (UKM, Malaysia); Nazmus Shaker Nafi (Kellogg Brown and Root, Australia); Azana Hafizah Mohd Aman (Universiti Kebangsaan Malaysia, Malaysia); Shayla Islam (UCSI University, Malaysia); Mohammed S Nahi (Imam AL-Kadhum College, Iraq)

The first non-profiled side-channel attack (SCA) method using deep learning is Timon's Differential Deep Learning Analysis (DDLA). Timon recommended this method. The method is effective in retrieving the secret key with the help of deep learning metrics. The Neural Network (NN) has to be trained numerous times since the proposed approach increases the learning cost with the key sizes, making it hard to assess the results from the intermediate stage. In this research, we provide three possible answers to the issues raised above, along with any challenges that could result from trying to solve these issues. We will start by offering an updated algorithm that has been modified to be able to keep track of the metrics during the intermediary stage. Next, we provide a parallel NN structure and training technique for a single network. This saves a lot of time by eliminating the need to repeatedly retrain the same model. The newly designed algorithm significantly sped up attacks when compared to the previous one. Thus, we propose employing shared layers to overcome memory challenges in parallel structure and improve performance. We evaluated our approaches by presenting non-profiled attacks on ASCAD dataset and a ChipWhisperer-Lite power usage dataset. Power utilisation was studied using both datasets. The shared layers strategy we created was up to 134 times more successful than the prior technique when used to the ASCAD database.

pp. 80-83

Wednesday, November 29 13:30 - 15:30 (Australia/Melbourne)

S4: Session 4: Networks

Room 2

Chair: Leith H. Campbell (RMIT University, Australia)

13:30 ***Optimal Scheduling of Multipath Multicast with In-network Cache for One-to-many Transfer*** ☐ ☐

Ryota Fukuda, Masahiro Shibata and Masato Tsuru (Kyushu Institute of Technology, Japan)

The need for fast and efficient one-to-many file transfers is growing with the rapid increase in traffic among distributed servers for replicating and distributing large files. Assuming centrally-managed Software Defined Networking (SDN) environments, the authors have been developing a framework of one-to-many file transfers for networks with full-duplex links by which every receiver can fully utilize its own max-flow from the sender throughout the file transfer duration. In our framework, a file is divided into multiple blocks that are transmitted to receivers on a set of multicast trees according to a block transmission schedule designed for a given network topology with the locations of the sender and the receivers (called MPMC). Our previous study proposed an extension of MPMC in which the sender generates additional coded blocks from the original blocks and transmits those blocks, but it may suffer from the processing delays of encoding and decoding at the sender and all the receivers. Therefore, this paper proposes a new extension of MPMC (called Rainbow-MPMC) by incorporating in-network cache at tailored switches, in which a block in transmission can be replaced (overwritten) at a switch on the way by another block previously passing the switch and cached, instead of just being forwarded to downstream. Through a variety of network topology examples, we verify that many different optimal schedules of Rainbow-MPMC can be generated in a given network, each of which minimizes every receiver's reception completion time simultaneously while requiring a different number of block replacements. We also showed that the minimum number of block replacements among different optimal schedules varies significantly by network even over similar-sized networks.

pp. 84-91

14:00 ***Deep Learning based Path Planning using Integer Linear Programming Method to Teacher Signal*** ☐

Makoto Ito, Taiju Mikoshi and Kouichi Genda (Nihon University, Japan)

It is an important research topic to suppress the occurrence of congestion caused by rapid increases and decreases in traffic flowing within a network. Traffic Engineering is a technology for controlling such traffic and efficiently using network resources. For sophisticated traffic control, it is necessary to perform complex calculations, and the issue of calculation time cannot be ignored. To solve these problems, we proposed a centralized path planning method for congestion control using machine learning. This method shows that by using the Dijkstra method for the teacher signal, paths can be designed in a short calculation time while achieving a very high path estimation success rate and load balancing. In this paper, we use Integer Linear Programming for the teacher signal to further improve performance. It is expected that this will enable better load distribution than before. Through performance evaluation experiments, we demonstrate the effectiveness of our proposal in terms of bandwidth usage and calculation time on the maximum load link.

pp. 92-97

14:30 ***Meta-TFEN: A Multi-Modal Deep Learning Approach for Encrypted Malicious Traffic Detection and Classification*** ☐ ☐

RuoYang Gu (China)

Malware poses a significant threat to internet security. Existing deep learning-based methods for malware traffic detection typically rely on single-modal features, overlooking the heterogeneity of encrypted traffic, thus limiting their detection performance. To address this limitation, this paper proposes a multi-modal deep learning approach called Meta-TFEN for detecting encrypted malicious traffic. The method utilizes TCN, Bi-GRU, and LSTM to extract multi-modal features including the payload of secure transport layer protocols, statistical features, and TLS encryption behavior features. It employs an fusion network to capture the dependencies between modalities and integrates discriminative features to enhance detection performance. Additionally, this paper uses a meta-learning framework for classification to enable rapid deployment of the model. The performance of Meta-TFEN is evaluated on public datasets and its applicability in real-world environments is explored using real samples. The experimental results clearly demonstrate that the Meta-TFEN method surpasses other state-of-the-art methods in terms of accuracy.

pp. 98-104

15:00 ***Achieving Sub-meter Accuracy for 5G Localization at FR1 Bandwidth Limitations*** ☐ ☐

Bjarne Frischkorn (TU Dortmund University, Germany); Michael Knitter (University of Dortmund, Germany); Wolfgang Endemann (Dortmund University of Technology, Germany); Ruediger Kays (TU

Dortmund University, Germany)
This Paper describes an approach to achieve improved localization accuracy in indoor and other scenarios with close line of sight and echo paths. The approach makes use of statistical commonalities of the channel impulse response, arriving from line of sight and echo paths superposition. By using a rising edge detection algorithm, the presented approach achieves an accuracy of less than one meter for line-of-sight scenarios at 5G FR1 bandwidth limitations. The paper presents results derived from simulation and measurement to support the proposed approach. Compared to conventional peak detection algorithms, the accuracy increases by a factor of at least two.

pp. 105-109

Wednesday, November 29 15:30 - 16:00 (Australia/Melbourne)

AT1: Afternoon Tea

Venue: Level 6 Building 16 Green Brain, Swanston St

Wednesday, November 29 16:00 - 18:00 (Australia/Melbourne)

S5: Session 5: IoT and wireless

Room 1

Chair: Ron Addie (University of Southern Queensland, Australia)

16:00 ***Malicious Lateral Movement in 5G Core With Network Slicing And Its Detection*** ☐

Ayush Kumar and Vrizlynn L. L. Thing (ST Engineering, Singapore)

5G networks are susceptible to cyber attacks due to reasons such as implementation issues and vulnerabilities in 3GPP standard specifications. In this work, we propose lateral movement strategies in a 5G Core (5GC) with network slicing enabled, as part of a larger attack campaign by well-resourced adversaries such as APT groups. Further, we present 5GLatte, a system to detect such malicious lateral movement. 5GLatte operates on a NF container-host access graph built using host/container logs collected from the 5GC. Paths inferred from the access graph are scored based on selected filtering criteria and subsequently presented as input to a threshold-based anomaly detection algorithm to reveal malicious lateral movement paths. We evaluate 5GLatte on a dataset containing attack campaigns (based on MITRE ATT&CK and FiGHT frameworks) launched in a 5G test environment which shows that compared to other lateral movement detectors based on state-of-the-art, it can achieve higher true positive rates with similar false positive rates.

pp. 110-117

16:30 ***Sharing, Licensing, Buying, Selling and Operationalizing ML Models: A Deep Learning based Co-operative and Co-ordinated Security usecase*** ☐ ☐

Deven Panchal, Dan Musgrove, Isilay Baran and David Lu (AT&T, USA)

Many problems that utilize Machine Learning in fact require multiple cooperative efforts to train models on different data on different targets so as to then be able to utilize all these results or the models themselves to do certain tasks. Problems in Remote sensing, Cybersecurity, Network analytics lend themselves very well to this co-operative paradigm where models built elsewhere on other data can be of direct and immediate use or at least be retrained and used at a different site. These models could in fact also come from some other organization or company (model supplier) who might charge (monetize) the usage of these models to another organization or company (model consumer) who may want to deploy them for their own use. Model sharing becomes all the more important in scenarios in which the data is subject to data sovereignty and data location requirements and, requirements over data transfer like GDPR, CCPA, etc. This sharing, monetizing, licensing, writing terms of sale of the models can be done in a very easy and streamlined fashion using the Acumos Federation and Acumos Licensing components that have been built for the exact same purpose. In this paper, we will talk about Acumos Federation, Acumos Licensing and build an ML model to automatically classify different types of Distributed Denial of Service (DDoS) attacks. We will later see how to set up N-site wide federation across 'N' Acumos instances (N=3 in the paper for demo purposes, which could represent 3 companies or 3 different physical sites) to share and use the models built elsewhere to cooperate on the task of identifying DDoS attack types. This paper shows how we can set up a coordinated and cooperative defense against a cooperative attack like DDoS, and more generally solve a variety of problems from different industries in a cooperative fashion using ML with Acumos.

pp. 118-123

17:00 ***Nanoplasmonic Broadband Filters Using Broadside Edge Coupled Coplanar Waveguide*** ☐ ☐

Thirupathaiah Kola (Koneru Lakshmaiah Education Foundation Hyderabad, India & Abu Dhabi University, United Arab Emirates); Montasir Qasymeh (Abu Dhabi University, United Arab Emirates); Ramakrishna Akella (Koneru Lakshmaiah Education Society, India)

This article presents the study and numerical analysis of three new broadband filters such as broadband bandpass filters based on broadside edge coupled coplanar waveguide with double-sided parallel step impedance resonators (SIRs) at optical frequency bands. The designed three broadband filters can perform effectively with a lower than 1 dB pass-band insertion loss. The basic transmission line characteristics of the broadside coupled CPW for the even-mode and odd-mode excitations are determined by using the quasi-static conformal mapping technique. These three filters are designed within a higher impedance transmission line section inserted between two lower impedance transmission line sections using cross-coupled resonance conditions. Among all these three filters, filter (III) gives better performance at optical frequencies, which is designed based on the design of the other two initial filters (I), (II). Due to their well-balanced characteristics, these filters provide both broadband operation and ultra-compact circuit size and are useful in the design of nanoscale subwavelength wireless networks.

pp. 124-127

17:30 ***Ergodic Performance Analysis of Reconfigurable Intelligent Surface Enabled Bidirectional NOMA*** ☐ ☐

Ashish Rauniyar (SINTEF, Norway); Olav Østerbø (Olav Østerbø & Telenor, Norway); Jan Erik Håkegård (SINTEF, Norway); Paal Engelstad (University of Oslo, Norway)

This paper proposes and investigates a reconfigurable intelligent surface (RIS) enabled bidirectional nonorthogonal multiple access (NOMA) network termed as NOMA-RIS. Here, RIS allows multiple NOMA users in one group to communicate with or share information with multiple NOMA users in another group. Specifically, the two NOMA user groups send the data intended for exchange to the RIS. RIS reflects the NOMA signals allowing bidirectional communication between two NOMA user groups. In particular, under the Rician fading environment, we pay close attention to how well RIS-enabled bidirectional NOMA networks operate. Analytical expressions for tight upper bounds for the ergodic capacity are mathematically derived and verified with the simulation results. Comprehensive performance comparisons are presented, showing that our proposed bidirectional NOMA-RIS system can achieve enhanced capacity gains than RIS-enabled traditional orthogonal multiple access schemes. These comparisons also offer practical insights into the impact of various system parameters on the overall network performance.

pp. 128-133

Wednesday, November 29 16:00 - 18:00 (Australia/Melbourne)

S6: Session 6: Networking and General

Room 2

Chair: Shuo Li (RMIT University, Australia)

16:00 ***Comprehensive Browser Extension for Analysing YouTube User Engagement, Controversy, User Requirements, and Trending Keywords*** ☐ ☐

Praveen Peiris, Thursha Herath, Roshani Dissanayaka, Kanishka Saranga, Samantha Thelijjagoda and Ishara Weerathunga (Sri Lanka Institute of Information Technology, Sri Lanka)

In the dynamic realm of YouTube, addressing the diverse needs of its extensive audience while empowering content creators is of paramount importance. This research paper introduces a robust solution encapsulated in a Chrome extension, meticulously designed to enhance user engagement and fortify YouTube content creators, specifically in the sphere of information technology-related videos. Our approach leverages state-of-the-art Natural Language Processing (NLP) methodologies and Machine Learning (ML) techniques. The extension provides a comprehensive suite of four critical functionalities: analysis of user engagement, extraction of user requirements, identification of controversial topics, and provision of invaluable keyword and title recommendations. To achieve these goals, we employed a range of techniques and algorithms, including Random Forest, VADER (Valence Aware Dictionary and Sentiment Reasoner) Lexicon, Multinomial Naïve Bayes (MNB), Latent Dirichlet Allocation (LDA), Bag of Words (BOW), and the GPT-3 model. The system boasts an impressive overall accuracy of 89.72%, with individual components achieving accuracies of 83.04%, 92.83%, 94%, and 89%, respectively. Beyond its direct application to information technology-themed YouTube content, the methodologies presented can be adapted for other platforms and a variety of categories, such as entertainment, gaming, cooking, travel, and tourism, among others. This research not only redefines the possibilities in YouTube analytics but also offers tangible tools and insights to help creators optimize engagement and foster deeper online dialogues.

pp. 134-139

16:30 ***Zero Trust Security Framework for 5G MEC Applications: Evaluating UE Dynamic Network Behaviour*** ☐

Belal Ali (RMIT, Australia); Mark A. Gregory and Shuo Li (RMIT University, Australia); Omar Amjad Atieh Dib (KCST University, Kuwait)

This paper presents a Zero Trust Security (ZTS) framework that enhances the security of Multi-Access Edge Computing (MEC) applications and services for 5G / 6G mobile networks. The ZTS framework incorporates a zero trust policy engine deployed in the 5G Core (5GC) network, which assesses User Equipment (UE) trustworthiness to access the MEC applications. The policy engine evaluates the UE Dynamic Network Behaviour (UDNB). Interactive procedures were designed to realise the proposed framework in a 3GPP-defined 5G network. Cooperation between mobile operators and vertical industries is achieved by leveraging the 5G Network Exposure Function and open interfaces. We propose that behaviour entropy be used as a quantitative measure to evaluate the UE trust value. An access control matrix was developed based on UE behaviour attributes. The performance evaluation demonstrates the effectiveness of our scheme in preventing unauthorised access to various MEC applications.

pp. 140-144

17:00 ***Service-driven User Plane Architecture for Future Cellular Networks and Multi-access Edge Computing*** ☐

Bin Liang (RMIT University, China); Mark A. Gregory and Shuo Li (RMIT University, Australia)

The proliferation of 5G applications that delay sensitive has increased demand for computing and storage capability at the network edge. User mobility results in frequent reallocation application state between edge servers and increased User Plane Function (UPF) requirements. Currently there is a complicated interaction between the Control Plane (CP) and User Plane (UP) that reduces the effective utilisation of network and computation resources, and degrades the Quality of Service (QoS). A service-driven UP selection mechanism plays a key role in fulfilling the heterogeneous service requirements, such as low latency and high speed, and the trade-off between cost and performance. This paper focuses on optimizing Xn-based post-handover UP management in 5G/6G networks by enabling the Uplink Classifier (ULCL) function and Application Function (AF) with refined QoS flow in the integration of 5G/6G with a multi-access edge computing environment. A service-driven UP reallocation mechanism and architecture are proposed for dynamic UP management to balance resource cost and performance.

pp. 145-151

17:30 ***Server Search and Selection Algorithm for a Pre-Handover in Multi-Access Edge Computing*** ☐

Shaima Alkaabi, Mark A. Gregory and Shuo Li (RMIT University, Australia)

MEC technology has become instrumental in enhancing the efficiency of content delivery, particularly at the network's edge, facilitating the rise of 5G and the evolution towards 6G. Within MEC, handover is a fundamental technology crucial to maintaining uninterrupted service provision and enhancing reliability. The need for handover is to guarantee seamless transitions between different network access points or cells, ensuring that users and devices are connected and receive consistent, high-quality service as they move. This work presentsan MEC Server Search and Select Algorithm (SSSA) employed during the pre-handover stage for optimization and a seamless handover between MEC servers. SSSA ensures uninterrupted, high-quality service with reduced latency, optimizing MEC's operational efficiency and reliability during the handover process. We discuss the cost equation with four network metrics for the server search and selection process in detail in this paper.

pp. 152-155

Thursday, November 30 8:30 - 10:30 (Australia/Melbourne)

S7: Session 7: Optical networking

Room 1

Chair: Farhad Arpanaei (Universidad Carlos III de Madrid, Spain)

8:30 ***Clipping Noise Mitigation for Coherent OFDM Systems Using Decision-Aided Reconstruction Combined with Neural Networks*** ☐ ☐

Alexander Frömming and Lars Haering (University of Duisburg-Essen, Germany); Stefan Diederich (Universität Duisburg Essen, Germany); Andreas Czylwik (Universität Duisburg-Essen, Germany)

Clipping noise constitutes a prominent challenge within transmission systems employing orthogonal frequency division multiplexing (OFDM) due to its high peak-to-average power ratio (PAPR). This paper introduces a novel algorithm for mitigating clipping noise at the receiver end of a coherent transmission system. The approach utilizes a recurrent neural network (RNN), specifically based on long short-term memory (LSTM) cells, to reduce the initial symbol error probability by reconstructing the clipped signal in time domain. Subsequently, an adapted iterative decision-aided reconstruction (DAR) algorithm is proposed. This algorithm incorporates two major improvements: Oversampling in time domain, which allows the filtering of residual out-of-band clipping noise after the nonlinear combination, and a novel method for phase management during reconstruction within a coherent system. Numerical simulations show the superior performance of the neural network in comparison to model-based strategies in terms of reducing the initial symbol error probability. Moreover, the application of oversampling and filtering achieves an additional performance gain. Finally, the symbol error ratio can be further reduced by exclusively combining magnitudes during a nonlinear combination process while retaining the phase of the received signal. The interaction of the neural network with the proposed algorithm is able to reduce the symbol error probability by up to five orders of magnitude, solely by processing the identical received signal.

pp. 156-161

8:54 ***Analysis of Adapted Tone Reservation PAPR Reduction Techniques in OTSM System*** ☐ ☐

Rafee Al Ahsan, Fadhel Ghannouchi and Abraham O Fapojuwo (University of Calgary, Canada)

Orthogonal time sequency multiplexing (OTSM) is one of the novel modulation candidates which has been recently proposed for future 6G wireless communications, as it outperforms the well-known orthogonal frequency division multiplexing (OFDM) and orthogonal time frequency space (OTFS) systems in terms of bit error rate (BER) and computational complexity, respectively in a high-mobility doubly dispersive wireless channel. However, a current analysis reveals that OTSM suffers from a very high peak-to-average power ratio (PAPR) problem like the conventional OFDM. As a result, this paper takes the initiative of analyzing the efficacy of the adapted versions of the classical tone reservation (TR) PAPR reduction technique in the sequency-delay domain of the new OTSM systems, in terms of PAPR reduction gains, computational complexity and BER performance as currently, none exists in the literature. This research reveals how the TR can be adapted with reserved-tone vectors (RVs) to the new delay-sequency domains and how its PAPR reduction capability and computation complexity vary with each new algorithmic change. The results provide analytical and simulation-wise insights into the newly-adapted TR (A-TR) algorithms in OTSM systems which will prove to be useful for carrying out future research in 6G.

pp. 162-168

9:18 ***From Strings to Streams: A Multi-Period Analysis of QKD over EONs, Showcasing Multi-Band vs. Multi-Fiber Solutions*** ☐ ☐

Mohammad Reza Dibaj (AmirKabir University of Technology, Iran); Pouya Mehdizadeh, Mohammad Sadegh Ghasrizadeh and Hamzeh Beyranvand (Amirkabir University of Technology, Iran); Juan Carlos Hernandez-Hernandez (University Carlos III de Madrid, Spain); José Alberto Hernández, David Larrabeiti and Farhad Arpanaei (Universidad Carlos III de Madrid, Spain)

Quantum key distribution over optical networks has been noted as a state-of-the-art approach to next-generation secure communication. We propose two approaches to manage the signal for quantum key exchange between two trusted nodes; in the first approach, the quantum channel (QCh) uses distinct fiber whereas the classic channel (CCh) and public interaction channel (PICh) use another fiber to be transmitted on C-band (C+L band), and in the second approach CCh and PICh are transmitted over C+L band and QCh only uses O-band, both routed on a same fiber. In this context, two variations of the initial approach have been put forth, namely scenario 1 and scenario 2. In scenario 1, the CChs are positioned within the extended C-band, while in scenario 2, they find their place within the extended C+L-band. Concerning the secondary approach, denoted as scenario 3, the CChs and QChs+PIChs are situated in the extended C+L-band and low-loss O-band, respectively. The simulation outcomes demonstrate the advantages of adopting scenario 3 in relation to fiber deployment. This is highlighted by an 86% (34%) enhancement in fiber efficiency when compared to scenario 1 (2), all while employing an equal count of quantum transmitters and receivers over the initial eight years. As per the specifications of scenario 3, during the concluding year, there has been a notable 44% surge in quantum transmitter and receiver utilization for both scenarios 1 and 2. This upsurge is accompanied by a substantial reduction in fiber utilization, amounting to a 117% (34%) reduction concerning scenario 1 (2).

pp. 169-175

9:42 ***Using Intent Directed Acyclic Graphs in Multi-Domain IP-Optical Networks*** ☐

Filippos Christou and Andreas Kirstaedter (University of Stuttgart, Germany)

The global internet relies on a well-coordinated operation of distinct networking domains. This renders multidomain networking at the heart of today's massive digital information exchange. Although Software-Defined Networking (SDN) undoubtedly helps advance network operation within a single organization, non-centralized multi-domain networking has received less attention. To significantly advance the state of networking, we are inherently bound to provide progress and evolve the current multi-domain networking scheme. This work exploits the Intent-Based Networking (IBN) paradigm and the Directed Acyclic Graphs (DAGs) data structure to design a novel architecture for multi-domain IP-Optical networking. We highlight the benefits of our approach leading to seamless operation of non-centralized networks, such as optically transparent domain boundaries and cross-domain grooming. We evaluate this approach in a realistic scenario using our novel open-source tool MINDFul.jl, which we shortly introduce and can be broadly used for related research.

pp. 176-179

10:06 ***Modulation Bandwidth Study on SQW GaN LEDs for High-speed Visible Light Communication*** ☐ ☐

Md Jahid Faruki (Monash University, Australia); Nemai Karmakar (MONASH University, Australia)

Modulation bandwidth of Light Emitting Diode is an important parameter for visible light communication system performance. Crystal orientation of an LED plays an important role in determining the modulation bandwidth. In this study, 5 different crystal orientations based GaN LEDs have been simulated to understand the impact of crystal orientations on recombination rates, carrier lifetime, and modulation bandwidth to meet the industry requirements for high-speed visible light communication applications.

pp. 180-182

Thursday, November 30 8:30 - 10:30 (Australia/Melbourne)

S8: Session 8: IoT

Room 2

Chair: Navid Shaghaghi (Santa Clara University, USA)

8:30 ***Optimizing Data Latency for Time-Critical Avionic Sensors*** ☐ ☐

Yevhenii Shudrenko (Hamburg University of Technology, Germany); Koojana Kuladinithi (Hamburg University of Technology & Institute of Communication Networks, Germany); Daniel Plöger and Andreas Timm-Giel (Hamburg University of Technology, Germany)

Wireless Sensor Networks (WSNs) are widely used in industries, healthcare, and smart cities due to their cost-effectiveness, low power consumption, and seamless connectivity. In aviation, the Wireless Avionics Intra-Communication (WAIC) standard aims to integrate WSNs, replacing some wired communication within aircraft for enhanced redundancy and new applications. We propose and evaluate the 6TiSCH with Hybrid Priority Queuing (6TiSCH-HPQ) mechanism, which differentiates traffic by

priorities on the link layer. 6TiSCH-HPQ improves Quality of Service (QoS) for time-critical avionic applications without compromising the performance of other traffic types. Analytical modeling with queuing theory and simulations in OMNeT++ demonstrate that up to three times reduction of the end-to-end delay for high-priority traffic is feasible.

pp. 183-189

8:54 ***Multi Sensor Network System for Early Detection and Prediction of Forest Fires in Southeast Asia*** ☐ ☐

Evizal Abdul Kadir (Universitas Islam Riau, Indonesia); Akram Alomainy (Queen Mary University of London, United Kingdom (Great Britain)); Hanita Daud (Universiti Teknologi PETRONAS, Malaysia); Warih Maharani (Telkom University, Indonesia); Muhammad Noryanti (Universiti Malaysia Pahang Al-Sultan Abdullah, Malaysia); Nesi Syafitri N (Universitas Islam Riau, Indonesia)

The increasing frequency and severity of forest and land fires have become a significant environmental concern, necessitating the development of effective early detection and prediction systems. This paper presents a novel approach to address the issue through the implementation of a multi sensor network system for forest and land fires. The proposed system integrates an array of advanced multi sensors strategically placed across the targeted regions to capture and analyze a wide range of fire related data. The key objective of the system is to enable timely identification of potential fire hotspots by continuously monitoring various environmental parameters, including temperature, humidity, and infrared radiation. The collected data is then processed and analyzed using machine learning algorithms to identify fire patterns and predict the likelihood of fire outbreaks. The system is utilizing a network of sensors, the system offers real-time and comprehensive coverage, allowing for rapid response and timely deployment of fire suppression resources. Furthermore, the results of extensive field tests and evaluations, demonstrating the system accuracy and efficiency in early fire detection and prediction. The proposed system offers a case in Indonesia which Riau Province with high-risk case most of every year. Plotting results data achieved and forecasting of incident for future in the year 2023 with successfully percentage up to 93.6%. Ultimately, the integration of the multi sensor network system into existing fire management frameworks promises to enhance emergency response capabilities and foster proactive measures in preserving our valuable forests and lands.

pp. 190-195

9:18 ***A LoRa-Based Monitoring System for Agriculture*** ☐

Steven Cumming and Philip Branch (Swinburne University of Technology, Australia)

In this paper, we present a LoRa-based monitoring system implementing LoRa with simple MAC (medium access control) architecture as a lightweight alternative to the more complex LoRaWAN systems for agricultural applications. Our developed system consists of several low cost and low power remote sensor nodes with LoRa transceivers in a star topology with a custom-built .NET data-logging and control application acting as the central node. Despite using LoRa without LoRaWAN, we were able to demonstrate the reliable collection of remote sensor data and control of remote nodes through field trials of the novel system conducted on a working cattle farm.

pp. 196-203

9:42 ***A Deep Learning-based Air Quality Index Prediction Model using LSTM and Reference Stations A Real Application in Taiwan*** ☐ ☐

Ping-Hui Hsieh, Ming-Hui Hu, Hsin-Hsiung Chen and Shih-Jung Wang (Ministry of Environment, Taiwan)

Air pollution has attracted significant attention as a public concern, prompting government efforts towards air quality monitoring. With the accumulation of data, the feasibility of utilizing artificial intelligence (AI) to aid in air quality prediction has grown. Air quality prediction plays a pivotal role in policy formulation and environmental management. We proposed a neural network model framework constructed using LSTM (Long Short-Term Memory) model and fully connected model. It employs pollutant and meteorological data from target stations, neighboring stations, and outpost stations as feature factors. By utilizing the previous 24 hours monitoring data, it predicts the hourly air quality index (AQI) for the next 12 hours. Experimental results demonstrated the effectiveness of this approach in enhancing prediction accuracy and providing early forecasts of long-range transport of air pollutants. This prediction model is applied within Taiwan Air Quality Monitoring Network [1] and Environment Info Push app [2] both maintained by Ministry of Environment of Taiwan (MOENV), allowing citizens to access information of environment at any time and receive activity recommendations based on real-time monitoring values.

pp. 204-209

10:06 ***Sensor-Centric Link Adaptation and Transmit Power Control for Energy-Efficient and Quality-of-Service WBANs*** ☐

Da-Ren Chen (National Taichung University of Science and Technology, Taiwan)

Due to the imbalanced power supply and computing capabilities between sensors and the coordinator in Wireless Body Area Networks (WBANs), challenges arise in terms of shortening service duration and increased delay for computation and data transmission tasks. To address this issue while meeting Quality of Service (QoS) requirements, Transmit Power Control (TPC) and Link Adaptation (LA) techniques, widely used in cellular or WiFi communications, are applied to determine suitable transmit power level and modulation and coding schemes (MCS) to enhance energy efficiency. The proposed reinforcement learning algorithm leverages latent path loss and shadowing (PLS) and Signal-to-Noise Ratio (SNR), and transmit power to effectively exploit the corresponding transmit power level and MCS, enabling efficient learning. It aims to minimize energy consumption while satisfying target QoS requirements, including data rate and error ratio. We adapt both models using an efficient Levenberg- Marquardt-Fletcher (LMF) method. By integrating LMF and dTS over the received channel SNR and PLS, the proposed approach automatically adapts to the channel SNR and fading conditions surrounding the human body. The results demonstrate that our method achieves significant power savings, with transmit energy reductions of up to 11.1%. Additionally, it extends the operating time of the sensors by up to 22.4% compared to existing methods.

pp. 210-213

Thursday, November 30 10:30 - 11:00 (Australia/Melbourne)

MT2: Morning Tea

Thursday, November 30 11:00 - 11:45 (Australia/Melbourne)

K3: Keynote - Automation and Orchestration of 5G Network Slices across RAN, Core, and Transport domains in the context of 5G Network Slicing

Sukhdev Kapur, Juniper Networks

Room 1

Chair: Mark A. Gregory (RMIT University, Australia)

Thursday, November 30 11:45 - 12:30 (Australia/Melbourne)

L2: Lunch

Venue: Level 6 Building 16 Green Brain, Swanston St

Thursday, November 30 12:30 - 16:30 (Australia/Melbourne)

T1: Conference Tour

meet outside Building 16, Swanston St

Thursday, November 30 16:30 - 18:00 (Australia/Melbourne)

W2: Workshop 2: 5G Labkit Demonstration

Ms Safa Alghadi, RMIT University, Lukman Iwan, RMIT University

Room 2

Chair: Safa Yahia Alghadi (RMIT University, Australia)

Supports 4G and 5G Standalone (SA) 5G Non-Standalone (NSA) support with optional additional radio Supports all sub-6 GHz frequency bands in TDD and FDD Supports LTE-M Integrates 4G and 5G Firecell Core & RAN Smartphone with SIM included O-RAN split 7.2 compatible via SFP+ port

Thursday, November 30 18:00 - 22:00 (Australia/Melbourne)

D1: Conference Dinner

Level 6, Building 16, Green Brain, Swanston St

Friday, December 1

Friday, December 1 8:30 - 10:30 (Australia/Melbourne)

S9: Session 9: IoT and General

Room 1

Chair: Jahan Hassan (Central Queensland University, Australia)

8:30 ***Functional Programming for the Internet of Things: A LoRa-MQTT Gateway written in Elixir*** ☐

Philip Branch and Phillip Seth Weinstock (Swinburne University of Technology, Australia)

Networks for the Internet of Things typically use a gateway to provide connectivity between a low bit rate, low capability sensor network and the broader Internet. The gateway can be subject to very high traffic loads, many concurrent processes and needs to be highly reliable. Functional programming languages such as Erlang and Elixir have proven to be an effective programming paradigm for such scenarios, notably in large scale telecommunications switches. In this paper we report on our experiences of developing a gateway between a LoRa network and an MQTT broker using the functional programming language Elixir. Our experience suggests that the discipline imposed by functional programming results in a system that is more compact, supports concurrent processes well and is more reliable than similar systems developed using conventional languages. However, we also note that subsystems to support the development of such systems are primitive and that functional programming has a considerably steep learning curve. Nevertheless we conclude that functional programming has considerable potential for the Internet of Things and plan to continue research in this area.

pp. 214-217

8:54 ***RSU placement considering V2X services requirements and available radio resources*** ☐ ☐ ☐

Camilo Anzola-Rojas, Ramón J. Durán Barroso, Juan Carlos Aguado, Ignacio de Miguel and Noemí Merayo (Universidad de Valladolid, Spain); Patricia Fernández, Rubén M. Lorenzo and Evaristo J. Abril (University of Valladolid, Spain)

Connected, cooperative and automated mobility (CCAM) is a growing field as the services required by connected vehicles increase in quantity and complexity. To be able to be connected, vehicles need network infrastructure to communicate with. Roadside Units (RSUs) are communication devices that are placed beside highways and roads and offer connectivity and processing services to the vehicles. The 3rd Generation Partnership Project (3GPP) has developed some standards which specify the characteristics of the services, as well as the spectral bands used to offer vehicle to everything (V2X) connectivity. In this paper, we study the optimal placement of RSUs in a V2X network for different service requirements and channel quality scenarios, considering the 3GPP standards. We formulate an Integer Linear Programming (ILP) model to minimize the number of RSUs needed and solve it for different traffic and channel conditions given by the 3GPP specifications. Results offer the number of required RSUs and their placement for vehicular access networks deployments.

pp. 218-221

9:18 ***On the Spatial Correlation of UAV-to-Ground Excess Path-Loss*** ☐ ☐

Mohammed Elsagher (RMIT, Australia); Akram Al-Hourani and Ke Wang (RMIT University, Australia)

Non-terrestrial networks have been gaining momentum in recent years as an integral part of current 3GPP releases and future networks. It is imperative to capture the intrinsic features of the Unmanned Aerial Non-terrestrial networks have been gaining momentum in recent years as an integral part of current 3GPP releases and future networks. It is imperative to capture the intrinsic features of the Unmanned Aerial Vehicle (UAV)-to-Ground radio channel to achieve higher throughput and minimize interference. One such aspect that has been overlooked thus far is the spatial correlation in the shadowing component of the excess path-loss resulting from near-ground clutter. In this article, we investigate the spatial correlation in the Excess Path-Loss caused by the propagation environment. We employ controlled and extensive ray-tracing simulations to explore the impact of different scenarios, ranging from suburban and urban to high-rise, on the spatial correlation of excess path-loss. We present a systematic method for processing the collected simulation data and propose an empirically derived expression for the spatial correlation in each use case. The results reveal a distinct variation in the spatial correlation of the excess path-loss across various city models, mandating a distinct correlation model for each scenario.Vehicle (UAV)-to-Ground radio channel to achieve higher throughput and minimize interference. One such aspect that has been overlooked thus far is the spatial correlation in the shadowing component of the excess path-loss resulting from near-ground clutter. In this article, we investigate the spatial correlation in the Excess Path-Loss caused by the propagation environment. We employ controlled and

extensive ray-tracing simulations to explore the impact of different scenarios, ranging from suburban and urban to high-rise, on the spatial correlation of excess path-loss. We present a systematic method for processing the collected simulation data and propose an empirically derived expression for the spatial correlation in each use case. The results reveal a distinct variation in the spatial correlation of the excess path-loss across various city models, mandating a distinct correlation model for each scenario.

pp. 222-227

9:42 ***International Deployment of Visual IoT for Disaster Mitigation*** ☐ ☐

Ken T. Murata (National Institute of Information and Communications Technology & NICT, Japan); Kazutaka Kikuta, Tsutomu Nagatsuma and Hideo Imanaka (National Institute of Information and Communications Technology, Japan); Praphan Pavarangkoon (King Mongkut's Institute of Technology Ladkrabang, Thailand)

This paper proposes a novel methodology that utilizes a newly developed visual Internet of Things (IoT) system for resilient natural disaster mitigation. This system enables the detection of disasters through remote control functions integrated with visual IoT sensors and artificial intelligence (AI)-based image processing of images captured by these sensors. The system is designed using commercial off-the-shelf (COTS) components to reduce installation costs, making it feasible for deployment worldwide, including in developing countries. In 2023, the proposal for this system was presented to the ITU-D with the aim of widespread implementation in developing nations. The paper introduces innovative methodologies for visual IoT in international disaster mitigation, accompanied by use cases and detailed technological insights.

pp. 228-233

10:06 ***Assessing the Capability of Random Forest to Estimate Received Power in LoRaWAN for Agricultural Settings using Climate Data*** ☐ ☐

Boris Ramos (Escuela Superior Politécnica del Litoral (ESPOL), Ecuador); Nelson Tovar, Jr (ESPOL, Ecuador); Edison I Del Rosario (Escuela Superior Politecnica del Litoral, Ecuador)

Low power wide area networks (LPWANs) such as LoRaWAN, enable long range wireless communication for internet of things (IoT) devices implemented in different settings, including agricultural crop fields. However, estimating RSSI values for these devices remains a challenge, due to the multipath effect, weather conditions, and the dynamic environment that surrounds these networks. This research evaluates the capability of a low-cost system that uses Random Forest Regression and climate data to estimate RSSI values in a LoRaWAN network deployed in a maize crop field. The Random Forest model uses eleven days of available data from twenty-nine nodes placed at different locations and heights in a maize crop field. In addition, the weather variables used as inputs to the model include temperature, humidity, and solar radiation. The model proved its efficacy to predict RSSI values for a recently inserted node in the network, and when it was used to forecast future and unknow RSSI values of a particular node.

pp. 234-239

Friday, December 1 8:30 - 10:30 (Australia/Melbourne)

S10: Session 10: Networks and Security

Room 2

Chair: Tomotaka Wada (Kansai University, Japan)

8:30 ***Evaluation of RTT as an estimation of interactivity time for QoE evaluation in remote desktop environments*** ☐ ☐

Jesus Arellano-Uson (Public University of Navarre, Spain); Eduardo Magaña and Daniel Morato (Universidad Publica de Navarra, Spain); Mikel Izal (Public University of Navarra (UPNA), Spain)

In recent years, there has been a notable surge in the utilization of remote desktop services, largely driven by the emergence of new remote work models introduced during the pandemic. Traditional evaluation of the quality of experience (QoE) of users in remote desktop environments has relied on measures such as round-trip time (RTT). However, these measures are insufficient to capture all the factors that influence QoE. This study evaluated RTT and interactivity time in an enterprise environment over a period of 6 months and analysed the suitability of using RTT drawing previously unexplored connections between RTT, interactivity, and QoE. The results indicate that RTT is an insufficient indicator of QoE in productive environments with low RTT values. We outline some precise measures of interactivity needed to capture all the factors that contribute to QoE in remote desktop environments.

pp. 240-245

8:54 ***Pedestrian-Vehicle Collision Avoidance Support System Considering the Left and Right Positions of Pedestrians*** ☐ ☐

Sota Uchida (University of Kansai, Japan); Hikaru Shimada and Tomotaka Wada (Kansai University, Japan); Naohisa Hashimoto (National Institute of Advanced Industrial Science and Technology, Japan)

The increase in the number of automobiles has caused social problems such as traffic accidents and chronic traffic congestion in urban areas. We focus on the Pedestrian-Vehicle Collision Avoidance Assistance System (P-VCASS), which assists drivers in avoiding collisions between vehicles and pedestrians. P-VCASS warns a driver when a potential collision is predicted. However, this method does not consider differences in danger depending on the position of pedestrians in a pedestrian crossing. In addition, it does not assume the case where there are multiple pedestrians. To solve these problems, we propose a warning system that assumes multiple pedestrians and calculates the degree of danger by considering the left and right positions of pedestrians. The effectiveness of the proposed system is demonstrated through experiments using vehicle and pedestrian terminals in pedestrian crossings. The results show that the proposed system can calculate the degree of danger for each pedestrian and provide appropriate warnings to drivers.

pp. 246-251

9:18 ***Hybrid Encryption Technique for Low-Latency Multi-Hop Communications*** ☐ ☐

Hye Yeon Shim and Tae Rim Park (Sungshin University, Korea (South)); Il-Gu Lee (Sungshin Women's University, Korea (South))

With the recent widespread use of 5G networks, real-time ultra-high-definition multimedia applications, video conferencing, and telecommuting have become possible. As a result, ultra-low-latency communication has become essential for ensuring human safety. In addition, as attacks on communication data gradually increase with the development of networks, packet encryption is applied to most services to protect data. However, in a multi-hop encrypted communication environment, it is challenging to achieve the low latency required for communication due to the significant overhead of encryption and decryption during information processing at the intermediate node. Conventional routing path optimization and caching techniques have evolved to reduce latency. However, the improvement in latency is significantly diminished in multi-hop encryption communication. Therefore, research is needed on low-latency and high-reliability encryption communication methods in a multi-hop communication environment. To this end, this paper proposes a hybrid encryption technique. The proposed technique improves latency while maintaining memory usage at a similar level in a multi-hop encrypted communication environment. Experimental results show that the proposed technique could reduce latency by an average of 10% compared to single-encrypted communication.

pp. 252-258

9:42 ***Anomaly Detection via Federated Learning*** ☐ ☐

Marc Vucovich (Deloitte, USA); Amogh Suhas Kamat Tarcar and Penjo Rebelo (Persistent Systems Limited, India); Abdul Rahman, Dhruv Nandakumar and Christopher Redino (Deloitte & Touche LLP, USA); Kevin Choi (Deloitte and Touche LLP, USA); Robert Schiller (Deloitte, USA); Sanmitra Bhattacharya and Balaji Veeramani (Deloitte & Touche LLP, USA); Alexandra West (Deloitte, USA); Edward Bowen (Deloitte & Touche LLP, USA)

Machine learning has helped advance the field of anomaly detection by incorporating classifiers and autoencoders to decipher between normal and anomalous behavior. Additionally, federated learning has provided a way for a global model to be trained with multiple clients' data without requiring the client to directly share their data. This paper proposes a novel anomaly detector via federated learning to detect malicious network activity on a client's server. In our experiments, we use an autoencoder with a classifier in a federated learning framework to determine if the network activity is benign or malicious. By using FedSam, our novel min-max scalar and sampling technique, we created a federated learning framework that allows the global model to learn from heterogenous clients and, in turn, provide a means for each client to improve their intrusion detection system's defense against cyber-attacks.

pp. 259-266

10:06 ***Ensemble Defense System: A Hybrid IDS Approach for Effective Cyber Threat Detection*** ☐ ☐

Sarah Alharbi (University of Delaware, USA); Arshiya Khan (Graduate Research Assistant, USA)

Sophisticated cyber attacks present significant challenges for organizations in detecting and preventing such threats. To address this critical need for advanced defense mechanisms, we propose an Ensemble Defense System (EDS). An EDS is a cybersecurity framework aggregating multiple security tools designed to monitor and alert an organization during cyber attacks. The proposed EDS leverages a comprehensive range of Intrusion Detection System (IDS) capabilities by introducing a hybrid of signature-based IDS and anomaly-based IDS tools. It also incorporates Elasticsearch, an open-source Security Information and Event Management (SIEM) tool, to facilitate data analysis and interactive visualization of alerts generated from IDSs. The effectiveness of the EDS is evaluated through a payload from a bash script that executes various attacks, including port scanning, privilege escalation, and Denial-of-Service (DoS). The evaluation demonstrates the EDS's ability to detect diverse cyber attacks.

pp. 267-270

Friday, December 1 10:30 - 11:00 (Australia/Melbourne)

MT3: Morning Tea

Friday, December 1 11:00 - 12:00 (Australia/Melbourne)

K4: Keynote - Addressing Data Leakage in Split Learning: Attacks and Defence Strategies

Professor Naveen Chilamkurti, Fellow IET (UK), La Trobe University

Room 1

Chair: Mark A. Gregory (RMIT University, Australia)

Split Learning (SL) has emerged as an innovative framework designed to enable deep learning applications on resource-constrained devices such as IoT or mobiles. Its core concept involves dividing a deep model into multiple parts and distributing them between data owners and a central cloud computing server. During the training process, only processed data is transmitted from the client to the server, safeguarding user data privacy. However, SL encounters several challenges, including (i) the high computational burden on low-end devices, (ii) potential privacy risks arising from the exposed intermediate data, and (iii) susceptibility to model inversion attacks capable of reconstructing raw input data. In this presentation, we will first delve into recent research addressing privacy attacks and defence mechanisms within the context of SL that could potentially lead to the leakage of users' private data. Subsequently, we will introduce our ongoing work aimed at enhancing the learning performance and privacy preservation of SL. This includes (i) the exploration of binarization in SL's local layers to expedite computation and reduce memory usage on the client side; (ii) an investigation into SL without local weight sharing to strengthen client-side data privacy, especially in environments with semi-trusted participants; and (iii) an examination of the integration of Differential Privacy into SL to further fortify user data privacy. We will identify potential accuracy degradation when training multiple clients with varying privacy requirements and present an approach to mitigate this challenge. By the end of this presentation, you will gain insights into the latest trends in the development of attacks and defences aimed at enhancing the privacy preservation of SL, which plays a crucial role in extending AI to pervasive devices while addressing data privacy concerns.

Friday, December 1 12:00 - 13:00 (Australia/Melbourne)

L3: Lunch

Venue: Level 6 Building 16 Green Brain Swanston St

Friday, December 1 13:00 - 15:00 (Australia/Melbourne)

S11: Session 11: Networks and Design

Room 1

Chair: Philip Branch (Swinburne University of Technology, Australia)

13:00 ***Enhancing Intent-driven Networking With Granular and Aspect Approach*** ☐

Nenad Dragun (Croatia); Nikola Bogunovic (University of Zagreb, Croatia)

Intent-driven networking propelled by new networking concepts as well as the introduction of achievements from machine learning and artificial intelligence domains in network management, has gained a significant momentum in telco networks automation realm. The fact of being closely related to machine learning and artificial intelligence domains, implied the necessity for its interaction with the knowledge management domain. Knowledge management supports intent-driven networking in various ways, ranging from user intent translation, across network feedback analysis, to activity deciding mechanisms. This paper presents the granular and aspect-driven approach in knowledge management as a convenient methodology intrinsically compatible with intent-driven core principles.

pp. 271-276

13:30 ***An Analysis of Pre-trained Models Versus Custom Deep Learning Models for Forest Fire Detection*** ☐ ☐

Shouthiri Partheepan (Central Queensland University & Eastern University, Australia); Farzad Sanati and Jahan Hassan (Central Queensland University, Australia)

The detection of forest fires is crucial for human and environmental safety due to their catastrophic impacts. Utilizing machine learning (ML) and deep learning (DL) enhances forest fire management by analyzing data, enabling early warning systems, monitoring fire behaviour, and optimizing resource allocation. The DL algorithms provide a significant influence in the context of forest fire detection. The result of many research studies in the recent past is evident that it is becoming increasingly important in future detection tasks. The majority of research studies use DL models that have been pre-trained. Nevertheless, an investigation should examine how custom models perform compared to pre-trained models in detection tasks. This study aims to compare the performance of the simple CNN model with that of the pre-trained DL model and also compare the pre-trained model as a feature extractor for the custom model. Five CNN pre-trained models, such as VGG16, ResNet50, MobileNetV2, Xception, and Inception were used for our study. The Xception model achieved high accuracy in both scenarios as a pre-trained model and feature extractor with custom layers for fire detection. Also, the result proved that combining CNN models as a feature extractor with custom layers performed well compared with the custom and pre-trained models.

pp. 277-282

14:00 ***Federated Learning Integration in O-RAN: A Concise Review*** ☐ ☐

Noureen Islam (Independent University Bangladesh, Bangladesh); Md Fahad Monir (Independent University, Bangladesh); M M Mahbubul Syeed (Independent University Bangladesh, Bangladesh); Mahady Hasan (Independant University Bangladesh, Bangladesh); Mohammad Faisal Uddin (Independent University Bangladesh, Bangladesh)

The rapid growth of the telecommunication industry presents a global challenge in maintaining data security and privacy amid increasing data traffic and diverse applications. Applying Federated Learning (FL) to the upcoming Next Generation Wireless Networks (NextG) or Open Radio Access Network (O-RAN) holds great potential as a solution for addressing these challenges. With this in consideration, our paper explores a secure and privacy-conscious solution, focusing on the potential of FL in upcoming wireless networks or O-RAN. FL's cooperative learning approach ensures data confidentiality, offering significant advancements in security issues associated with growing user numbers, and supports the migration to the NextG. In this paper, the concise review provides valuable insights into O-RAN, FL, and related works, with an emphasis on security and privacy. Additionally, it explores framework utilization and outlines future research directions for integrating FL within O-RAN. This approach aims to offer the readers a quick and clear understanding of FL integration within O-RAN, avoiding the need to navigate through extensive survey papers.

pp. 283-288

14:30 ***Understanding Statistical Correlation of Application Security Vulnerability Data from Detection and Monitoring Tools*** ☐

Santanam Kasturi and Xiaolong Li (Indiana State University, USA); John Pickard and Peng Li (East Carolina University, USA)

Vulnerability data gathered from multiple detection and monitoring capabilities at different layers of an application using a time-series analysis will provide value and insights by doing a statistical correlation with attack requests observed using a Web Application Firewall (WAF) monitoring solution. Static Analysis Security Testing, Software Composition Analysis, Dynamic Analysis Security Testing (DAST), Application Ethical Hack, Application Programming Interface (API) testing are the tests / scans that have been used to gather vulnerability data for this study. Correlations can further help track abnormal transaction paths if we follow specific ones pointed out by the statistical analysis for those requests that are not blocked by the rules and are allowed as valid transactions to pass through. This provides a narrowed down focus on the convergence of observability and security, critical to realizing a near-real time rapid action. Observations must continue for many days as a time series ensuring consistency and reliability in data collections and analysis. Multiple applications must be observed in a similar manner for ensuring validity of the process for analysis. Also, gathering sufficient data that is large enough to represent a reasonable population of web applications within an organization is a significant factor in achieving reliable correlation. Applying Pearson Correlation (or Spearman Correlation for distributions that are not normal) technique provides insight into Significance (two-tailed) as to whether a correlation is present over large number of data points. Results of analysis show evidence of correlations among specific attack requests monitored by the WAF and corresponding vulnerabilities in applications, detected using one or more methods. This is significant to looking for more insights into how these correlations can further explored into predicting attack patterns based on existing vulnerabilities.

pp. 289-296

Friday, December 1 13:00 - 15:00 (Australia/Melbourne)

S12: Session 12: Wireless and Security

Room 2

Chair: Mohammad Hasan (UKM, Malaysia)

13:00 ***Information-Theoretic Security in BB84 QKD*** ☐

Shawn Arnold Prestridge, James Dunham and Dinesh Rajan (Southern Methodist University, USA)

This paper demonstrates ways to improve the post-processing phase of BB84-based Quantum Key Distribution (QKD) while maintaining Information-Theoretic security. Maximum entropy in the distilled bits can be achieved provided that we follow certain rules on which bits are sacrificed, and these rules follow naturally from the properties of the generator matrix. We use standard decoder techniques to distill bits and establish Information-Theoretic security, but give insights into how those techniques can be adapted to provide greater bit throughput. Finally, we compare popular coding schemes in BB84 post-processing as a basis for code selection and discover at low initial Bit Error Rates (BER), a Polar 4/5 or Hamming *give the best performance and for higher initial BER, the LDPC 3/4 and Hamming* give the best performance.

pp. 297-303

13:24 ***An RF-based Low Rate DDoS Attack Real-time Detection System*** ☐ ☐ ☐

Shijin Liu and Hiroaki Fukuda (Shibaura Institute of Technology, Japan); Paul Leger (Universidad Católica del Norte, Chile)

Software Defined Networking (SDN) is a new paradigm in network architecture. It improves network flexibility, scalability and network management by separating data forwarding logic and control logic. SDN controllers have a global view of the entire network and provide the ability to dynamically change traffic forwarding rules. However, the introduction of SDN brings some new vulnerabilities to DDoS attacks, such as single point of failure. DDoS attack is a network attack that floods network links by transferring illegal traffic at high speed. Illegal data traffic can overload network links, causing legal data to be lost and network services to be unavailable. Low Rate Distributed Denial of Service (LRDDoS) is the latest evolution of DDoS attacks and has become one of the most serious vulnerabilities in the Internet, cloud computing platforms, the Internet of Things (IoT), and large data centers. LRDDoS attacks consume network resources by periodically sending a relatively small number of packets. Therefore, LRDDoS attacks are more difficult to detect. This paper proposes a real-time system for LRDDoS defense in SDN. The system uses Random Forest(RF) to detect attacks. We call this system as RFLRS. In addition, we propose a feature subset that is the most suitable for RFLRS for reducing the classification time based on the CIC dataset. Our experimental results show that RF performs a 99.8% accuracy with a reduction of 28% classification time.

pp. 304-309

13:48 ***Combining Decentralized IDentifiers with Proof of Membership to Enable Trust in IoT Networks*** ☐ ☐

Alessandro Pino, Davide Margaria and Andrea Vesco (LINKS Foundation, Italy)

The Self-Sovereign Identity (SSI) is a decentralized paradigm enabling full control over the data used to build and prove the identity. In Internet of Things networks with security requirements, the Self-Sovereign Identity can play a key role and bring benefits with respect to centralized identity solutions. The challenge is to make the SSI compatible with resource-constraint IoT networks. In line with this objective, the paper proposes and discusses an alternative (mutual) authentication process for IoT nodes under the same administration domain. The main idea is to combine the Decentralized IDentifier (DID)-based verification of private key ownership with the verification of a proof that the DID belongs to an evolving trusted set. The solution is built around the proof of membership notion. The paper analyzes two membership solutions, a novel solution designed by the Authors based on Merkle trees and a second one based on the adaptation of Boneh, Boyen and Shacham (BBS) group signature scheme. The paper concludes with a performance estimation and a comparative analysis.

pp. 310-317

14:12 ***TGP-based dynamic traffic camouflage method*** ☐ ☐

Hao Yu (China)

n order to address the issue of attackers leveraging traffic analysis to steal users' network behavioral patterns, this paper proposes a dynamic traffic camouflage method based on Twin Gaussian Processes (TGP). TTC utilizes Twin Gaussian Processes to capture the pattern changes in the target traffic for feature prediction of the undisguised traffic. After obtaining the predicted features, constraints are applied and traffic reconstruction is performed based on these constrained features. The reconstructed traffic is indistinguishable from the target traffic, leading to misclassification by attackers. Experimental results using the ISCXTor2016 public dataset demonstrate that the proposed TTC method has stronger obfuscation capabilities in traffic classification compared to previous traffic obfuscation methods. It effectively protects user privacy.

pp. 318-324

14:36 ***Design of Lightweight Cryptography Based Deep Learning Model for Side Channel Attacks*** ☐

Amjed Ahmed (Imam Kadhim (A) for Isalmic Science University, Iraq); Mohammad Hasan (UKM, Malaysia); Nazmus Shaker Nafi (Kellogg Brown and Root, Australia); Azana Hafizah Mohd Aman (Universiti Kebangsaan Malaysia, Malaysia); Shayla Islam (UCSI University, Malaysia); Saif Aamer Fadhil (Imam Al Kadhum College IKC, Iraq)

Depending on the device's encryption mechanism, a wide variety of tangible details could be exposed. These leaks are used in side-channel analysis, which is used to get keys. Due to deep learning's sensitivity to the characteristics of the data being processed, using such algorithms can significantly improve the accuracy and efficiency of side channel analysis. However, classic neural networks are now used for the vast majority of the work that is being done. When the number of nodes in a network grows, so does the efficiency with which key recovery can function. However, the method's computing complexity grows in direct proportion. Overfitting, inadequate capacity for feature extraction, and inefficient training are all potential issues. In this study, we develop a compact convolutional neural network by enhancing a previously existing combination of characteristic network. Novel network of neural nature along with previous neural network both have their own implementations of the side-channel analysis used in comparative trials. Statistically, the new network has better accuracy, quicker convergence, and more robustness. Overfitting did not occur in any of the cases. As part of the research, heatmaps were provided as a means of data visualisation. The critical interval concentration is higher and the heat value is higher in the new network. Conventional neural networks, which serve as the foundation for various kinds of neural networks, perform much worse than side channel studies based on feature fusion networks.

pp. 325-328

Friday, December 1 15:00 - 15:30 (Australia/Melbourne)

AT3: Afternoon Tea

Venue: Level 6, Building 16 Green Brain, Swanston St

Friday, December 1 15:30 - 15:40 (Australia/Melbourne)

CR: Closing Remarks

ITNAC 2024 is in Sydney, Australia

Mark Gregory, General Chair, RMIT University

Chair: Mark A. Gregory (RMIT University, Australia)

Venue: Level 6 Building 16 Green Brain, Swanston St

附錄 4、出國期間照片

圖 1.會議報告場地（RMIT Storey Hall and Green Brain）

圖 2.本部發表運用人工智慧進行未來 12 小時 AQI 預測之論文

圖 3.與報告場次主席 Navid Shaghaghi (Santa Clara University, USA)攝於會場

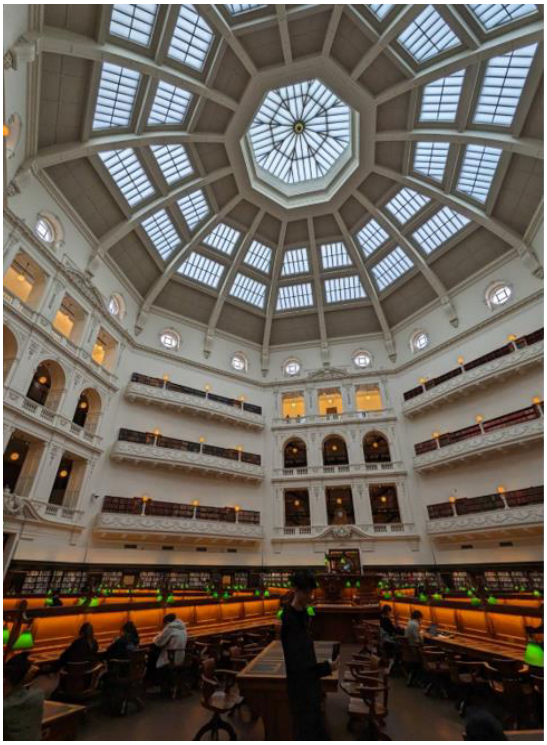

圖 4.會議參訪維多利亞州立圖書館(The State Library of Victoria)（左）及墨爾本板球場(Melbourne Cricket Ground)（右上、右下）

圖 5. Xinghuo Yu(RMIT, IEEE Fellow)進行主題演講