

PERSONALISATION FRAMEWORK FOR MALAYSIAN m-GOVERNMENT
SERVICE

NOOR SURIANA BINTI ABU BAKAR

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Information Systems)

School of Computing
Faculty of Engineering
Universiti Teknologi Malaysia

FEBRUARY 2022

DEDICATION



I wish to express my great gratitude to my beloved parents (*Abu Bakar & Rohana*)
for everything they have done for me.

I thank all to my beloved sisters and brothers *Ida, Anim, Aisyah, Syafiqah, Shahril,*
Rasyid and family members, thank you for your patience, understanding and support.

And I would like to extend my deepest gratitude to my late husband, *Yusri Abdullah,*
who always support and encourage me to finish my study. My beloved daughters
Annur Najihah Yusri, Alya Safiyyah Yusri and Anis Humaira Yusri, who have given
me unconditional love and purity that lights up my days. They are most important
person in my life. Thanks for giving me a happy family. With no doubt, the endless
love of my family help me survive in this adventure.

ACKNOWLEDGEMENT

All praise and thanks are due to Allah the Almighty in whom I put my trust. There is no power and no strength, save with Allah, the High, the Great. Indeed, without Allah's most gracious compassion, this thesis would not have been completed. His blessing is due to hardship and dua' and there is no powerful dua' except dua' from our parents. Thank you to my parents – Abu Bakar Abdul Manaf & Rohana Haron - who have always make dua' and supported me endlessly.

My sincere appreciation goes to my two wonderful supervisors, Assoc. Prof. Dr. Haza Abdull Hamed and Assoc. Prof. Dr. Azizah Abdul Rahman for encouragement, guidance and motivation throughout this research. I truly have learned a lot under their supervision. They have awarded me with generous support, and their assistance are invaluable in my research process. Their direction leads to the accomplishment of my thesis. This thesis might not perfect ever, however my shortcomings in presenting my PhD research is filled by positive comments and suggestion from the examiners. A big thank you to Prof. Dr. Shamsul Anuar Mokhtar and Assoc. Prof Dr. Roliana Ibrahim for their positive input and comments.

Along the way my PhD journey is also supported by individual and groups. Thank you to those individual and groups (FB – Doctorate Support Group), and the list is endless as Allah send many people that contributed either directly or indirectly. My gratitude also goes to the staff at the IS department and my fellow friends of PhD IS programme and my labmate (Rashidah, Ravika, Deborah, Kak Mas and others) at School of Computing. My sincerely thank you to Madam Engku Anisah, Madam Nadisah Mohamad, Madam Adawiyah Md Ashar and teams at Application Development Division (ADD), MAMPU for their cooperation, support, positive input and comments. Thank you all for your support.

ABSTRACT

Mobile Government (m-Government) is an implementation strategy involving all types of mobile technology services and applications to enhance the benefits of citizens, businesses and all government units. Due to the escalating number of m-Government services developed annually, citizens face difficulties finding the appropriate government services according to their needs which indirectly lead to information overload. There is a gap in the existing m-Government personalisation framework which is deficient in personalisation efficiency and intelligence and is weak at data management. The current m-Government services are limited to simple online presentations, and intelligent services are highly desirable. The aim of this study was to propose a Personalisation Framework for Malaysian m-Government services (Pe-mGov) to better understand the needs of citizens toward the m-Government services. Three research objectives guided this study; firstly, to identify and categorise the m-Government services for the Malaysian citizens; secondly, to design a personalisation framework for Malaysian m-Government services (Pe-mGov); and thirdly, to evaluate the applicability of personalisation framework through the development of predictive model. A Design Science Research methodology was used to solve the problems to ensure this framework would be rigour and relevance. In this study, five steps were involved in developing the framework namely, firstly, categorisation of m-Government services; secondly, data collection; thirdly, storage of data regarding citizen profiles and feedback; fourthly, cluster analysis and predictive model; and fifthly, model evaluation and validation. The demographic and services variables were the dependent variables used for utilizing the two-step cluster technique. The multinomial logistic regression was used to estimate the independent associations, obtaining the odds ratios and 95% confidence intervals. Three clusters were generated, namely, firstly, working people; secondly, non-working people and thirdly, students. The findings showed that the accuracy of the predictive model was 92.0% and the model is an excellent fit to recommend the m-Government service. Besides, this proposed framework can be used as a guide to assist government agencies in promoting m-Government services among citizens.

ABSTRAK

Perkhidmatan Mudah Alih Kerajaan (m-Kerajaan) adalah strategi pelaksanaan yang melibatkan semua jenis perkhidmatan dan aplikasi teknologi mudah alih untuk meningkatkan manfaat kepada rakyat, perniagaan dan semua unit dalam kerajaan. Disebabkan oleh peningkatan jumlah perkhidmatan m-kerajaan yang dibangunkan setiap tahun, rakyat menghadapi kesukaran untuk mendapatkan perkhidmatan kerajaan yang sesuai mengikut keperluan mereka yang secara tidak langsung membawa kepada maklumat yang berlebihan. Terdapat jurang dalam kerangka pemperibadian m-Kerajaan sedia ada di mana terdapat kekurangan kecekapan dan kecerdasan pemperibadian serta lemah dalam pengurusan data. Perkhidmatan m-kerajaan semasa adalah terhad kepada persembahan dalam talian yang mudah dan perkhidmatan pintar sangat diinginkan. Matlamat penyelidikan ini adalah untuk mencadangkan Kerangka Pemperibadian untuk perkhidmatan m-Kerajaan Malaysia (Pe-mGov) untuk lebih memahami keperluan rakyat terhadap perkhidmatan m-Kerajaan. Tiga objektif kajian menjurus ke arah kajian ini, pertama, untuk mengenal pasti dan mengkategorikan perkhidmatan m-Kerajaan untuk warganegara Malaysia; kedua, untuk mereka bentuk kerangka keperibadian untuk perkhidmatan m-Kerajaan Malaysia (Pe-mGov); dan ketiga, untuk menilai kebolegunaan kerangka personalisasi melalui pembangunan model ramalan. Metodologi Penyelidikan Sains Reka Bentuk telah digunakan untuk menyelesaikan masalah bagi memastikan kerangka ini adalah tegar dan sesuai. Dalam kajian ini, lima langkah terlibat dalam membangunkan rangka kerja iaitu, pertama, pengkategorian perkhidmatan m-Kerajaan; kedua, pengumpulan data; ketiga, penyimpanan data mengenai profil rakyat dan maklum balas; keempat, analisis kelompok dan model ramalan; dan kelima, penilaian dan pengesahan model. Pembolehubah demografi dan perkhidmatan adalah pembolehubah bersandar yang digunakan untuk menggunakan teknik kelompok dua langkah. Regresi logistik multinomial digunakan untuk menganggar pembolehubah tidak bersandar, mendapatkan nisbah kemungkinan dan selang keyakinan 95%. Tiga kelompok telah dijana iaitu, pertama, orang bekerja; kedua, orang tidak bekerja; dan ketiga, pelajar. Dapatan kajian menunjukkan ketepatan model ramalan ialah 92.0% dan model tersebut sangat sesuai untuk mengesyorkan perkhidmatan m-Kerajaan. Selain itu, kerangka kerja yang dicadangkan ini boleh digunakan sebagai panduan untuk membantu agensi kerajaan dalam mempromosikan perkhidmatan m-Kerajaan di kalangan rakyat.

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LIST OF ABBREVIATIONS

APAD	-	Land Public Transport Agency
DBP	-	Malay Language Search in Institute of Language and Literature
DOF	-	Department of Fisheries
GAMMA	-	Gallery of Malaysian Government Mobile Applications
IM	-	Immigration Department
JAKIM	-	Department of Islamic Development
KDN	-	Ministry of Home Affairs
KeTTHA	-	Ministry of Energy, Green Technology and Water
KPKT	-	Ministry of Housing and Local Government
KWP	-	Ministry of Federal Territory
MACC	-	Malaysian Anti-Corruption Commission
MaHTAS	-	Malaysia Health Technology Assessment Section
MAMPU	-	Malaysian Administrative Modernisation and Management Planning Unit
MARA	-	Council of Trust for the Bumiputera
MDTCC	-	Ministry of Domestic Trade, Cooperatives and Consumerism
MEC	-	Malaysian Examinations Council
MOE	-	Ministry of Education
MOF	-	Ministry of Finance
MOH	-	Ministry of Health
MOHR	-	Ministry of Human Resources
MOSTI	-	Ministry of Science, Technology and Innovation
MOTAC	-	Ministry of Tourism, Art and Culture
MOW	-	Ministry of Works
RELA	-	Malaysian Volunteerism Corps Department
RMP	-	Royal Malaysian Police

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CHAPTER 1

INTRODUCTION

1.1 Overview

Modern technological advancements have transformed government services to benefit citizens, firms and public agencies via mobile government (m-Government) initiatives. m-Government is defined by Kushchu and Kuscu (2003) as "*strategy and implementation involving all types of mobile technology services and application to enhance the benefits of citizens, businesses and all government units*". The introduction of m-government is seen to complement existing forms of services provided by the government. The aim is to help residents use these services without difficulty. The Organisation for Economic Co-operation and Development (OECD) states that m-Government initiatives are extensions of electronic government (e-Government) programmes. Business transactions, services and information dissemination are accomplished in an online environment where mobile devices deliver public services (OECD/ITU, 2011).

Mobile applications enable the dissemination of all information in real-time, positively impacting the service sector (Muller *et al.*, 2014). Government agencies are developing mobile technologies that better facilitate user interactions while improving service quality (Abdelghaffar and Magdy, 2012). In 2020, there was 6.1 billion smartphone users globally, and this number surpasses the number of active fixed-line subscriptions worldwide (Rana *et al.*, 2019). Boundless possibilities await services that can be communicated and delivered through smartphones, including programmes for employment, healthcare, education, taxes, transportation, agriculture, law enforcement, and judicial/legal systems (Mengistu *et al.*, 2009). Smartphones are essential personal instruments for managing everyday activities, with vast numbers of active mobile subscribers in both the developing and developed world (Hussain and Imran, 2014). The dominance of the smartphone paradigm throughout the world

provides communication channels in an interactive and timely manner that tremendously ease the ways in which citizens access public services. The platforms provide convenient, real-time access to helpful information. The personalisation of information assures that the benefits of using such information are maximised (Mengistu *et al.*, 2009).

By empowering all citizens, m-Government initiatives improve the quality of life for the majority who were digitally excluded before. According to Su and Jing (2010), it was noted that the mobile devices of today are essential in most people's lives. This has been confirmed by Onashoga *et al.* (2016) who mentioned that mobile devices have become an important tool. Governments have come to realize this since they have opted to begin using mobile devices to provide their services to citizens (El-Kassas *et al.*, 2017). The prevalence of mobile devices has enabled service outreach, providing better access to groups that are often hard to reach such as senior citizens, those with disabilities or those who live in rural areas (OECD/ITU, 2011; Isagah and Wimmer, 2017). Mobile devices specifically facilitate easier access to public services and information.

Such technological advancements offer public institutions an opportunity to involve users in their course of service. Technology can further enhance the government's performance and cooperation among government agencies. Government agencies can gain advantages from using mobile and wireless technologies as delivery channels since they possess the following features: continuous availability, location-centric, convenience, customisation and identifiability (Zamzami and Mahmud, 2012). The combination of new technology of m-Government with existing services can transform the nature of government services, and citizens will feel closer and more inclined to participate in these operations (OECD/ITU, 2011).

1.2 Problem Background

Currently, the m-Government programme is implemented in mobile networks and is rapidly expanding by extending its reach to delivering public services. Strategies and implementation phases for all types of digital services and applications now

provide public programmes and information to citizens, firms and government agencies (Hussain and Imran, 2014). The government has applied the innovation system, information and communication technologies to provide advanced and efficient services, interact with citizens more effectively, provide more convenient and timely transaction services and increase citizen participation (Ayachi *et al.*, 2016).

Although the benefits of these programmes are numerous in delivering enhanced services, implementation for most m-Government programmes are still in their early stage (Muller *et al.*, 2014). Despite the tremendous efforts made by governments in developing countries to expand their mobile networks, such services are still largely unexploited and unnoticed by citizens (Mengistu *et al.*, 2009; Alshammari *et al.*, 2018). Mobile devices that serve as channels for accessing government services have been a critical concern for several government agencies, particularly when citizens have access to public services from multiple government agencies via the internet through their mobile devices. The quality of information provided through m-Government mobile technology is seen as one of the most critical dimensions towards organisational achievement and success (Zamzami and Mahmud, 2012).

According to the World Bank (2012), over half of the world population regularly uses the internet, but most do not use m-Government services due to ignorance regarding the usage potential of these services (Alssbaiheen and Love, 2015). The government service mainly sends information through SMS or makes it available on the Web. Much of the information is static with little interaction from citizens (OECD/ITU, 2011). Citizens in many countries still prefer the traditional channels for communicating and interacting with government departments, and this fact is reflected in the low adoption rate of electronic services (Almuraqab, 2016).

In Malaysia, the great market penetration of smart mobile phones has compelled agencies to provide high-quality services via m-Government programmes. However, the statistics reveal that there is still a low usage rate of citizens using m-Government services (Ishak and Muhammad Arif, 2019). According to Al-Thunibat *et al.* (2010), Malaysian m-Government services are plagued with problems such as

lack of personalised features, difficulty to find relevant services, lack of security and privacy as well as poor quality of service. The government's digitalisation plan aims to enhance citizen service delivery by focusing on the delivery process to improve responsiveness and expand service outreach (MAMPU, 2018).

Governments are currently offering a variety of m-Government services and applications. m-Government is categorised into several groups based on the task and technology used. The purpose of categorisation services is to provide a variety of m-Government services and to gain further insight regarding services offered in both developed and developing countries. m-Government mostly offers informational and operational services rather than transactional services (Sheng and Trimi, 2008). According to Hussain and Imran (2016), most applications are documented in the literature but far less have been actually developed. Wide-ranging innovative approaches and applications have not been examined or implemented for further knowledge building and sharing (Hussain and Imran, 2016). Therefore, categorising services will aid government agencies in providing different services, making it easier for citizens to identify services that meet their needs.

For m-Government services to be successful, implementation should be tailored to the needs of individual users to provide them with personalised information based on their perceptions, reactions and demands (Germanakos *et al.*, 2014). Personalisation services are an additional strategy that can enhance benefits by increasing citizen engagement and satisfaction (OECD/ITU, 2011). Personalisation is defined as the ability to provide services and content that have been tailored to individuals based on their behaviour information and preferences (Adomavicius *et al.*, 2008). The main aim of personalising m-Government services is to deliver relevant services to citizens. This will ensure that the needs and preferences of its target users are understood (Alsbaiheen and Love, 2015).

Several countries have succeeded in increasing citizen awareness and the use of their services through m-Government portals by focusing on personalisation, such as Canada, Denmark, Hungary, Mexico and others (OECD, 2009). Based on previous research on personalisation framework development, Singapore and Canada have

offered their citizens simple personalisation services through their official website portals. However, this personalisation remains static and cannot offer a meaningful interaction (Abdellatif *et al.*, 2013). Another framework proposed by Mahmood and Abdul Salam (2013) highlights the technologies and techniques that can be considered in developing personalised services using mobile location-based and semantic web technology. The framework has delivered relevant user information in terms of preferences, but the contextual conditions seem to be lacking in most applications. According to Al-Hassan *et al.* (2011), m-Government services mainly focus on presenting information online and not actually providing personalised services. Every user who accesses the system will be presented with the same set of information. The user must determine which attractions and activities are interesting and suitable.

The Gallery of Malaysian Government Mobile Application (GAMMA) is a single digital platform that provides the public with the opportunity to view and download government applications directly via mobile devices. However, most services offered by the government still do not provide personalised services. Citizens require personalised services that are tailored to their needs and preferences (Al-Thunibat *et al.*, 2011). Existing personalisation frameworks may not be applicable for other countries, such as Malaysia, due to the difference in implementation requirements and m-Government context. Therefore, the new conceptual framework of personalised m-Government services from the aspect of citizens is proposed to be appropriate since it is in accordance with user preferences and personal needs, requiring the least input from users. The potential needs of citizens must be identified by examining the requirements of diverse groups of citizens and creating a successful service that integrates quality features that cater to everyday practical needs.

1.3 Problem Statement

Nowadays, mobile communication and wireless technology have a pivotal role in the lives of the citizen in Malaysia. The government of Malaysia has steadily increased the government services being offered on mobile platforms, thereby pressurising the market concerning the implementation of m-Government services and

mobile device penetration. Furthermore, the usage of such services by the citizens is not inspiring because the individuals face challenges in selecting the appropriate services amidst the ecosystem being overloaded with information (Al-Thunibat *et al.*, 2010; Shambour *et al.*, 2016).

The citizens desire to have services compatible with the present ecosystem with favourable characteristics like accessibility and uninterrupted availability (Al-Thunibat *et al.*, 2010; Cheng San *et al.*, 2017). Such moves will effectively increase the base for m-Government services. A personalisation framework was also developed to provide citizens with personalised m-Government services. However, the current personalisation frameworks are limited to simple online presentation, not providing personalised services and intelligent m-Government services are highly desirable (Al-Hassan *et al.*, 2011).

The challenges specified above may be addressed by bringing in personalisation framework that can effectively meet the needs of the citizens, be offered the way the individuals want, and also aid in increasing their use (Abdellatif *et al.*, 2013). Using the abovementioned points, the problem statement concerning this study is specified below:

There is a need to establish a personalisation framework for m-Government services to better understand the needs of users while assisting government agencies in the promotion of m-Government services among citizens.

1.4 Research Questions

The main research question of this study is “How personalisation can be applied to promote the m-Government services?”

This question can be divided into three sub-research questions:

1. What is the categorisation for the Malaysian m-Government services?

2. What is the appropriate personalisation framework for the Malaysian m-Government services?
3. How can the applicability of the personalisation framework be evaluated?

1.5 Research Objectives

There are three intended outcomes for this study based on the following research objectives:

1. To identify and categorise the m-Government services for the Malaysian citizens.
2. To design a personalisation framework for Malaysian m-Government services (Pe-mGov).
3. To evaluate the applicability of personalisation framework through the development of predictive model.

1.6 Scope of the Research

The scope of the research comprises four aspects:

1. The study focuses on m-Government Mobile Applications in Malaysia (GAMMA), in order to acquire the list of public services made available to citizens.
2. The target respondents included various levels of citizens: government staff, private staff, students, entrepreneurs, housewives, unemployed persons, and pensioners where they represent the categories of citizens in the population.
3. The study focuses on citizen who used or expressed interest to use the m-Government services.

4. The study focused on a mobile application since the government have shifted towards providing the convenient services to the citizens that can be accessed from anywhere and at any time by using a mobile device.

1.7 Significance of the Research

This study contributes to the novelty of the development of a personalisation framework for Malaysian m-Government services by focusing on the needs of the citizens and then recommending the appropriate services according to their profiles. The personalisation is embedded in the m-Government services because it can provide relevant information to the citizens; improve the reliability of the information, and save time and cost. Under the 12th Malaysian Plan, personalisation strategies can serve as a platform for improving digital communication (MAMPU, 2021).

In general, two groups of users will benefit from this study: the government agencies and the citizens who use the m-Government services. As for the government agencies, they can improve the quality of the services rendered by implementing a personalisation strategy in accordance with the public sector digitisation strategic plan (MAMPU, 2021). As a result, government agencies can increase the quality of the services delivered and offer the exact services that meet the citizens' needs. Securing information on citizens' background can be a huge stepping-stone to attract the target citizens to use the service. The initiative involves the categorisation of m-Government services, which would be useful for developing categorisation templates that help citizen identify categories of service offerings from government agencies. The data can be used to guide public agencies in the delivery of services that best meet the needs of citizens.

On the citizens' side, they can use the m-Government services quickly and easily. The overload navigation will not disturb their processes anymore. The personalisation strategy provided by the government can save the citizens' time and money because citizens will not need to queue up at the agency counters, and information is readily accessible anywhere and anytime. In addition, the suggested

user-profiling feature will help citizens by recommending the services that are appropriate to them based on the user profile. This research aims to provide insights and assist the government agencies to understand the citizens' needs for promoting the m-Government services amongst the citizens.

1.8 Disposition of the Thesis

This thesis comprises six chapters. Chapter 1 introduces the research topic and discusses the research background concerning m-Government personalisation programmes, as well as the establishment of a recommendation scheme. Statements of the research problem, questions, and study objectives are emphasised. The scope and significance of this research are also outlined in accordance with its contributions in the field. The chapter outline is explained as follows.

Chapter 2 contains the literature on the m-Government and a discussion on the m-Government services in Malaysia. The personalisation concept and clustering technique from previous studies were reviewed and analysed. Thus, the chapter sheds light on the theoretical framework.

Chapter 3 demonstrates the research design and methodology. The design science research (DSR) methodology was adopted for designing and developing the artefact in five steps: 1) Awareness of problem, 2) Suggestion to the problem, 3) Framework and model development, 4) Model evaluation and validation, and 5) Conclusion. The chapter concludes with a detailed description of the operational framework and the activities undertaken in this study.

Chapter 4 presents the design and development of the personalised framework for Pe-mGov. Importantly, it elaborates the process of designing and developing the artefact. The proposed Pe-mGov framework is described in detail in the chapter. There are five components of the framework: (1) Data collection; (2) Categorisation of m-Government services; (3) Storage of data regarding citizen profiles and citizen feedback; (4) Cluster analysis and predictive model; and (5) Model evaluation and validation.

Chapter 5 presents the evaluation and discussion. The chapter evaluates the applicability of the framework through the development of a predictive model. The user survey was then conducted among citizens through a predictive model to evaluate the effectiveness of the framework. The evaluation metrics including accuracy metric (precision and recall), coverage, diversity, novelty and serendipity that have been identified in the literature were used to evaluate the model. The chapter also presents the feedback for the improvement of the framework.

Finally, Chapter 6 concludes and presents the main contributions and research achievements of the study. The research limitations and future works are also discussed in this chapter.

REFERENCE

- Abdelghaffar, H. and Magdy, Y. (2012) 'The adoption of mobile government services in developing countries: The case of Egypt', *International Journal of Information and Communication Technology Research*, 2(4), pp. 333–341.
- Abdellatif, A., Ben Amor, N. and Mellouli, S. (2013) 'An intelligent framework for e-government personalized services', in *Proceedings of the 14th Annual International Conference on Digital Government Research - dg.o '13*, pp. 120–126.
- Abdrabbah, S. Ben, Ayachi, R. and Ben Amor, N. (2016) 'A dynamic community-based personalization for e-Government services', *ACM International Conference Proceeding Series*, 01-03-Marc, pp. 258–265.
- Abdullah, N. R. W., Mansor, N. B. and Hamzah, A. (2013) 'Keeping ahead of the game: Innovations and challenges in e-government in Malaysia', *Economic and Labour Relations Review*, 24(4), pp. 549–567.
- Abu Tair, H. Y. A. and Abu-Shanab, E. A. (2014) 'Mobile Government Services', *International Journal of Technology Diffusion*, 5(1), pp. 17–25.
- Addagarla, S. K. and Amalanathan, A. (2019) 'A survey on comprehensive trends in recommendation systems & applications', *International Journal of Electronic Commerce Studies*, 10(1), pp. 65–88.
- Adomavicius, G., Huang, Z. and Tuzhilin, A. (2008) *Personalization and Recommender Systems, State-of-the-Art Decision-Making Tools in the Information-Intensive Age*.
- Adomavicius, G. and Tuzhilin, A. (2005a) 'Personalization technologies', *Communications of the ACM*, 48(10), pp. 83–90.
- Adomavicius, G. and Tuzhilin, A. (2005b) 'Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions', *IEEE Transactions on Knowledge and Data Engineering*, 17(6), pp. 734–749.
- Aggarwal, C. C. (2016) *Recommender Systems*.
- Ahmad, M. (2007) 'Implementation of Electronic Government in Malaysia', *Public Sector ICT Management Review*, 1(1), pp. 1–9.

- Akosa, J. S. (2017) 'Predictive accuracy: A misleading performance measure for highly imbalanced data', *SAS Global Forum*, 942, pp. 1–12.
- Al-Badarenah, A. and Alsakran, J. (2016) 'An Automated Recommender System for Course Selection', *International Journal of Advanced Computer Science and Applications*, 7(3), pp. 166–175.
- Al-hassan, M., Lu, H. and Lu, J. (2009) 'A Framework for Delivering Personalized e-Government Services from a Citizen-Centric Approach', in *Proceedings of the 11th International Conference on Information Integration and Web-based Applications & Services*, pp. 436–440.
- Al-Hassan, M., Lu and Lu, J. (2011) 'Personalized e-Government Services : Tourism Recommender System Framework', in *International Conference on Web Information Systems and Technologies*, pp. 173–187.
- Al-Hujran, O. (2012) 'Toward the utilization of M-Government services in developing countries: A qualitative investigation', *International Journal of Business and Social Science*, 3(5), pp. 155–160.
- Al-Hujran, O. and Migdadi, M. (2013) *E-Government Implementation and Practice in Developing Countries*.
- Al-Khamayseh, S., Hujran, O, Aloudat, A. and Lawrence, E. (2006) 'Intelligent M-Government: Application of Personalisation and Location Awareness Techniques', *Journal of the American Society for Information Science*, 1(January), pp. 1–10.
- Al-Khamayseh, S., Hujran, Omar, Aloudat, A. and Lawrence, E. (2006) 'Intelligent m-government: application of personalization and location awareness techniques', *Journal of the American Society for Information Science*, 1(January), pp. 1–10.
- Al-Thunibat, A., Alrawashdeh, T. A. and Muhairat, M. (2014) 'The acceptance of using M-government services in Jordan', *Journal of Theoretical and Applied Information Technology*, 63(3), pp. 643–644.
- Al-Thunibat, A., Mat Zin, N. A. and Sahari, N. (2010) 'Mobile Government Services in Malaysia: Challenges and Opportunities', in *International Symposium Information Technology (ITSim)*, pp. 1244–1249.
- Al-Thunibat, A., Zin, N. and Sahari, N. (2011) 'Identifying User Requirements of Mobile Government Services in Malaysia Using Focus Group', *Journal of E-Government Studies and Best Practices*, 2011, pp. 1–14.

- Alabdulrahman, R., Viktor, H. and Paquet, E. (2019) 'Active learning and user segmentation for the cold-start problem in recommendation systems', in *IC3K 2019 - Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, pp. 113–123.
- Alberti, F. (2017) *Quantitative and Research*.
- Alhakami, H., Alraddadi, S., Alseady, S., Baz, A. and Alsubait, T. (2020) 'A Hybrid Efficient Data Analytics Framework for Stroke Prediction', *International Journal of Computer Science and Network Security*, 20(4), pp. 240–250.
- Allahyari, M., Assefi, M., Pouriyeh, S. and Trippe, E. D. (2017) 'A Brief Survey of Text Mining : Classification , Clustering and Extraction', *ACM*, (August), pp. 1–16.
- Almuraqab, N. A. S. (2016) 'M-Government Adoption Factors in the United Arab Emirates : A Partial Least-Squares Approach', *International Journal of Business and Information*, 11(4), pp. 404–432.
- Alomari, M. A., Ellrehail, H. H. and Al Shibly, H. (2013) 'Mobile-Government : Challenges and Opportunities Jordan as Case study Alomari Mohammad A . Balqa Applied University Balqa Applied University', *International Journal of Business and Social Science*, 4(12), pp. 244–250.
- Alotaibi, R., Houghton, L. and Sandhu, K. (2017) 'Factors Influencing Users' Intentions to Use Mobile Government Applications in Saudi Arabia: TAM Applicability', *International Journal of Advanced Computer Science and Applications*, 8(7), pp. 200–211.
- Alshammari, T., Cheung, Y. and Messom, C. (2018) 'M-government Adoption Research Trends : A Systematic Review', in *Australasian Conference on Information Systems*, pp. 1–11.
- Alshehri, M. and Drew, S. (2012) 'The Effects of Website Quality on Adoption of E-Government Service : An Empirical Study Applying UTAUT Model Using SEM E-Government : Background', (2011), pp. 1–13.
- Alssbaiheen, A. and Love, S. (2015a) 'Exploring the Challenges Of M-Government Adoption in Saudi Arabia', *The Electronic Journal of e-Government*, 13(1), pp. 18–27.
- Alssbaiheen, A. and Love, S. (2015b) 'The Opportunities and Challenges Associated With M-Government as an E-Government Platform in KSA : A Literature Review', *International journal of management studies*, 5(2), pp. 31–38.

- Ansari, Z., Azeem, M. F., Ahmed, W. and Vinaya Babu, A. (2011) 'Quantitative Evaluation of Performance and Validity Indices for Clustering the Web Navigational Sessions', *World of Computer Science and Information Technology Journal*, 1(5), pp. 2221–2741.
- Antwi, S. K. and Kasim, H. (2015) 'Qualitative and Quantitative Research Paradigms in Business Research: A Philosophical Reflection Performance Management Practices in the Ghanaian local government system View project', *European Journal of Business and Management*, 7(3), pp. 217–226.
- Arbelaitz, O., Gurrutxaga, I., Muguerza, J., Pérez, J. M. and Perona, I. (2013) 'An extensive comparative study of cluster validity indices', *Pattern Recognition*, 46(1), pp. 243–256.
- Asif, M. and Krogstie, J. (2011) 'Mobile student information system', *Emerald*, 28(1), pp. 5–15.
- Ayachi, R., Boukhris, I., Mellouli, S., Ben Amor, N. and Elouedi, Z. (2016) 'Proactive and reactive e-government services recommendation', *Universal Access in the Information Society*. Springer Berlin Heidelberg, 15(4), pp. 681–697.
- Azeez, N. D. and Lakulu, M. M. (2018) 'Evaluation framework of M-government services success in Malaysia', *Journal of Theoretical and Applied Information Technology*, 96(24), pp. 8194–8226.
- Badr, S. M. and Hussein, S. E. (2014) 'Cloud Based Public Collaboration System in Developing Countries', *International Journal of Advanced Computer Science and Applications*, 5(9), pp. 1–9.
- Bal, M., Biricik, C. G. and Sari, A. (2015) 'Dissemination of Information Communication Technologies: Mobile Government Practices in Developing States', *International Journal of Communications, Network and System Sciences*, 08(13), pp. 543–551.
- Bany Domi, K. K. H. and Mohamad, F. S. (2018) 'E-Government: Practices, Maturity, Models, Adoption and Factors', *Malaysian Journal of Computing and Applied Mathematics*, 1(1), pp. 29–38.
- Basamh, S. S., Qudaih, H. A. and Suhaimi, M. A. (2014) 'E-government implementation in the Kingdom of Saudi Arabia: an exploratory study on current practices, obstacles and challenges', *International Journal of Humanities and Social Science*, 4(2), pp. 296–300.

- Bataineh, M. M. and Jdaitawi, A. M. (2005) 'M-Government in Jordan : Today and the Future', in *Proceeding of the Fourth International Conference in Information Technology*, pp. 1–9.
- Batool, F. and Hennig, C. (2021) *Clustering with the Average Silhouette Width, Computational Statistics and Data Analysis*.
- Batra, A. (2011) 'Analysis and Approach: K-Means and K-Medoids Data Mining Algorithms', in *5th IEEE International Conference on Advanced Computing & Communication Technologies*, pp. 274–279.
- Batule, R. M. and Itkar, P. S. A. (2016) 'A Survey Paper on different Clustering techniques for Collaborative Filtering for services recommendation', *International Journal of Computer Science and Information Technologies (IJCSIT)*, 7(3), pp. 1410–1413.
- Berkhin, P. (2006) *Survey of Clustering Data Mining Techniques, Grouping Multidimensional Data: Recent Advances in Clustering*.
- Beshir Osman, N. and Mohammed Osman, I. (2013) 'Attributes for the Quality in Use of Mobile Government Systems', in *International Conference on Computing, Electrical and Electronic Engineering (ICCEEE)*, pp. 274–279.
- Bhagat, A., Kshirsagar, N., Khodke, P., Dongre, K. and Ali, S. (2016) 'Penalty Parameter Selection for Hierarchical Data Stream Clustering', *Procedia Computer Science*. Elsevier Masson SAS, 79(December), pp. 24–31.
- Bobadilla, J., Ortega, F., Hernando, A. and Gutiérrez, A. (2013) 'Recommender systems survey', *Knowledge-Based Systems*. Elsevier B.V., 46, pp. 109–132.
- Boon, L. S., Malek, J. A., Hussain, M. Y. and Tahir, Z. (2020) 'Participation in e-government services and smart city programs: A case study of Malaysian local authority', *Planning Malaysia*, 18(3), pp. 300–312.
- Bouhmala, N. (2016) 'How good is the euclidean distance metric for the clustering problem', *Proceedings - 2016 5th IIAI International Congress on Advanced Applied Informatics, IIAI-AAI 2016*, (September), pp. 312–315.
- Bozanta, A. and Kutlu, B. (2018) 'Developing a Contextually Personalized Hybrid Recommender System', *Mobile Information Systems*, 2018, pp. 1–13.
- Bozpolat, E. (2016) 'An Investigation of the Variables Predicting Faculty of Education Students' Speaking Anxiety through Ordinal Logistic Regression Analysis', *Journal of Education and Learning*, 6(1), p. 27.

- Brown, M. (2008) *An evaluation of the paper self completion questionnaire planned for use as part of 2008 sweep of the National Child Development Study, Centre for Longitudinal Studies.*
- Burke, R. (2007) ‘Hybrid web recommender systems’, in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, pp. 377–408.
- Burova, S. (2016) *Swinburne University of Technology Doctoral Thesis A data mining tool for predicting student withdrawal.*
- Çano, E. and Morisio, M. (2019) ‘Hybrid recommender systems: A systematic literature review’, *Intelligent Data Analysis*, 21(6), pp. 1487–1524.
- Chen, Y., Wu, C., Xie, M. and Guo, X. (2011) ‘Solving the sparsity problem in recommender systems using association retrieval’, *Journal of Computers*, 6(9), pp. 1896–1902.
- Cheng San, A. N., Yee, C. J., Moorthy, K. and Tun Lee, A. F. (2017) ‘Intention To Use M-Government Services: Age, Gender and Education Really Matter?’, *International Journal of eBusiness and eGovernment Studies*, 9(2), pp. 1–31.
- Cho, S., Kim, J. and Ha, B. (2015) ‘A Solution to Privacy Violation Problem in Korean Ubiquitous Government Service’, *Indian Journal of Science and Technology*, 8(25), pp. 1–6.
- Chulyadyo, R., Leray, P. and Leray, P. A. (2017) *A Framework for Offline Evaluation of Recommender Systems based on Probabilistic Relational Models.*
- Consonni, V., Ballabio, D. and Todeschini, R. (2010) ‘Evaluation of model predictive ability by external validation techniques’, *Journal of Chemometrics*, 24(3–4), pp. 194–201.
- Cortés-Cediel, M. E., Cantador, I. and Gil, O. (2017) ‘Recommender systems for e-governance in smart cities: State of the art and research opportunities’, in *ACM International Conference Proceeding Series*, pp. 1–6.
- Creswell, J. W. (2009) *Research Design: Qualitative, Quantitative and Mixed Approaches (3rd Edition), Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.*
- Creswell, J. W. and Plano Clark, V. L. (2019) *Book Review: Designing and conducting mixed methods research, HERD: Health Environments Research & Design Journal.*
- Cutajar, M. (2017) *Mobile Government Strategy.*

- Daniels, B. D. and Einstein, N. (2017) *The Value of Personalization*.
- Davidsson, C. (2010) *Mobile Application Recommender System*.
- Davies, D. L. and Bouldin, D. W. (1979) 'A Cluster Separation Measure', *IEEE Transactions on Pattern Analysis and Machine Intelligence*, PAMI-1(2), pp. 224–227.
- DOS (2017) *Department of Statistics Malaysia*. Available at: Department of Statistics Malaysia Official Portal (dosm.gov.my) [Assessed: 19 December 2017]
- DOSM (2019) *Demographic Statistic Malaysia*. Available at: Department of Statistics Malaysia Official Portal (dosm.gov.my) [Assessed: 20 September 2019]
- DOSM (2020) *Poket Stats Negeri Selangor*. Available at: Department of Statistics Malaysia Official Portal (dosm.gov.my) [Assessed: 20 February 2020]
- Duignan, P. (2004) *The Use of Formative Evaluation by Government Agencies*.
- El-Habil, A. M. (2016) 'An application on multinomial logistic regression model', *Pakistan Journal of Statistics and Operation Research*, 8(2), pp. 271–291.
- El-Kassas, W. S., Abdullah, B. A., Yousef, A. H. and Wahba, A. M. (2017) 'Taxonomy of Cross-Platform Mobile Applications Development Approaches', *Ain Shams Engineering Journal*. Ain Shams University, 8(2), pp. 163–190.
- Elgammal, A., Papazoglou, M., Krämer, B. and Constantinescu, C. (2017) 'Design for Customization: A New Paradigm for Product-Service System Development', *Procedia CIRP*. The Author(s), 64(December), pp. 345–350.
- Eriksson, P. and Kovalainen, A. (2016) *Introduction To Qualitative Data, Qualitative methods in business research (2nd ed.)*.
- Fadhil, N. A., Rozaini, W. A. N., Osman, S., Nather, I. T., Al-saadi, T. A. L. I. and Al-khafaji, N. J. (2014) 'Mobile Technology in the Iraq context: Design mobile application prototype for the election of directors for departments in the Ministry of Science', *Proceeding of SARC International Conference*, pp. 97–103.
- Fop, M. and Murphy, T. B. (2018) 'Variable selection methods for model-based clustering', *Statistics Surveys*, 12, pp. 18–65.
- Foss, A. H., Markatou, M. and Ray, B. (2019) 'Distance Metrics and Clustering Methods for Mixed-type Data', *International Statistical Review*, 87(1), pp. 80–109.
- Ge, M., Delgado-Battenfeld, C. and Jannach, D. (2010) 'Beyond accuracy', in *Proceedings of the fourth ACM conference on Recommender systems - RecSys '10*, p. 257.

- Geetha, G., Safa, M., Fancy, C. and Saranya, D. (2018) 'A Hybrid Approach using Collaborative filtering and Content based Filtering for Recommender System', *Journal of Physics: Conference Series*, 1000(1), pp. 0–7.
- Germanakos, P., Samaras, G., Mourlas, C. and Christodoulou, E. (2014) *Innovative Personalization Issues for Providing User-Centric mGovernment Services*, *ResearchGate*.
- Ghazanfar, M. A. and Prugel-Bennett, A. (2010) 'A scalable, accurate hybrid recommender system', in *3rd International Conference on Knowledge Discovery and Data Mining, WKDD 2010*, pp. 94–98.
- Ghyasi, A. F. and Kushchu, I. (2004) 'Uses of Mobile Government in Developing Countries', *Mobile Government Lab (mGovLab)*, May(May 2004), pp. 1–11.
- Gong, S. (2010) 'A Collaborative Filtering Recommendation Algorithm Based on User Clustering and Item Clustering', *Journal of Software*, 5(7), pp. 745–752.
- GSMA (2019) 'The Mobile Economy 2019', *GSMA Intelligent*, pp. 1–56.
- Guba, E. G. and Lincoln, Y. S. (2004) 'Competing Paradigms in Qualitative Research', *Approaches to Qualitative Research: A Reader on Theory and Practice*, pp. 17–38.
- Gunawardana, A. and Shani, G. (2009) 'A Survey of Accuracy Evaluation Metrics of Recommendation Tasks', *The Journal of Machine Learning Research*, 10, pp. 2935–2962.
- Gupta, J. and Gadge, J. (2014) 'A framework for a recommendation system based on collaborative filtering and demographics', in *2014 International Conference on Circuits, Systems, Communication and Information Technology Applications (CSCITA)*, pp. 300–304.
- Hassan, M., Jaber, T. and Hamdan, Z. (2014) 'Adaptive Mobile-Government Framework International Conference on Administrative Development : Towards Excellence in Public Sector Performance Adaptive Mobile- Government Framework Institute of Public Administration Riyadh , Saudi Arabia', in *International Conference on Administrative Development: Towards Excellence in Public Sector Performance Adaptive*, pp. 1–11.
- Hevner, A. and Chatterjee, S. (2010) *Design Research in Information Systems*.
- Hevner, A. R. (2007) 'A Three Cycle View of Design Science Research', *Journal of Information Systems*, 19(2), pp. 87–92.

- Hevner, A. R., March, S. T., Park, J. and Ram, S. (2004) 'Design Science Information', *MIS Quartely*, 28(1), pp. 75–105.
- Hevner, A. R., Park, J. and March, S. T. (2004) 'Design science in information systems research', *MIS Quarterly: Management Information Systems*, 28(1), pp. 75–105.
- Ho, S. Y. (2012) 'The effects of location personalization on individuals' intention to use mobile services', *Decision Support Systems*. Elsevier B.V., 53(4), pp. 802–812.
- Homburg, V., Dijkshoorn, A. and Thaens, M. (2014) 'Diffusion of personalized services among Dutch municipalities: Evolving channels of persuasion', *Local Government Studies*, 40(3), pp. 429–450.
- Homburg, V. M. F. (2013) 'Diffusion of personalized e-government services among Dutch municipalities', *Review of Applied Management Studies*. Instituto Politécnico do Cávado e do Ave (IPCA), 11(2), pp. 83–91.
- Horn, B. and Huang, W. (2016) 'Comparison of Segmentation Approaches', in *Decision Analyst*, pp. 1–12.
- Hu, L., Song, G., Xie, Z. and Zhao, K. (2014) 'Personalized Recommendation Algorithm Based on Preference Features', *Tsinghua Science and Technology*, 19(3), pp. 293–299.
- Hu, R., Dou, W. and Liu, J. (2014) 'ClubCF: A clustering-based collaborative filtering approach for big data application', *IEEE Transactions on Emerging Topics in Computing*, 2(3), pp. 302–313.
- Huang, E. Y. and Lin, C. (2005) 'Customer-oriented financial service personalization', *Industrial Management & Data Systems*, 105(1), pp. 26–44.
- Hume, A. (2014) 'Construct validation of a measure to assess sustainability of school-wide behavior interventions', *Journal of Psychology in the Schools*, 50(10), pp. 1003–1014.
- Hussain, M. and Imran, A. (2014) 'mGovernment services and adoption: Current research and future direction', *IFIP Advances in Information and Communication Technology*, 429, pp. 311–323.
- Irani, J., Pise, N. and Phatak, M. (2016) 'Clustering Techniques and the Similarity Measures used in Clustering: A Survey', *International Journal of Computer Applications*, 134(7), pp. 975–8887.

- Isagah, T. and Wimmer, M. A. (2017) ‘Mobile government applications: Challenges and needs for a comprehensive design approach’, in *ACM International Conference Proceeding Series*, pp. 423–432.
- Isagah, T. and Wimmer, M. A. (2018) ‘Addressing Requirements of M-Government Services’, in *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance - ICEGOV '18*, pp. 599–608.
- Ishak, M. A. and Muhammad Arif, A. M. (2019) ‘Intention To Use M-Government Services Among Consumers in Putrajaya’, *Jurnal Pengguna Malaysia*, 33, pp. 136–147.
- Isinkaye, F. O., Folajimi, Y. O. and Ojokoh, B. A. (2015) ‘Recommendation systems: Principles, methods and evaluation’, *Egyptian Informatics Journal*. Ministry of Higher Education and Scientific Research, 16(3), pp. 261–273.
- ITU (2011) *Benefit and outcomes of m-government, M-Government: Mobile Technologies for Responsive Governments and Connected Societies*.
- Jannach, D. and Friedrich, G. (2013) ‘Tutorial: Recommender Systems’, in *International Joint Conference on Artificial Intelligence*, pp. 1–144.
- Johanson, G. A. and Brooks, G. P. (2010) ‘Initial scale development: Sample size for pilot studies’, *Educational and Psychological Measurement*, 70(3), pp. 394–400.
- Jong, J. De (2016) *Data Collection : Self-Administered Surveys*.
- Jørstad, I., Thanh, D. Van and Dustdar, S. (2005) ‘The Personalization of Mobile Services’, in *IEEE International Conference on Wireless And Mobile Computing, Networking And Communications*, pp. 1–11.
- Kabir, S. M. S. (2016) *Methods of data collection, Basic Guideline for Research*.
- Kamaruddin, K. A. and Noor, N. L. (2017) ‘From e-government to t-government: A Malaysian citizen? readiness study’, *Journal of Telecommunication, Electronic and Computer Engineering*, 9(2–9), pp. 15–21.
- Khanali, H. and Vaziri, B. (2016) ‘A Survey on Clustering Algorithms for Partitioning Method’, *International Journal of Computer Applications*, 155(4), pp. 20–25.
- Khatwani, S. and Chandak, M. B. (2016) ‘Building Personalized and Non Personalized recommendation systems’, in *International Conference on Automatic Control and Dynamic Optimization Techniques, ICACDOT 2016*, pp. 623–628.

- Kirillov, Z., Shmorgun, I. and Lamas, D. (2011) 'Towards the design of Estonia's m-government services', *Proceedings of the 5th International Conference on Theory and Practice of Electronic Governance - ICEGOV '11*. New York, New York, USA: ACM Press, p. 61.
- Kivunja, C. and Kuyini, A. B. (2017) 'Understanding and Applying Research Paradigms in Educational Contexts', *International Journal of Higher Education*, 6(5), p. 26.
- Kobsa, A. (2007) *The Adaptive Web*. Available at: <https://book.asia/book/2071779/450e84>. [Assessed: 15 June 2019]
- Kohar, M. and Rana, C. (2012) 'Survey Paper on Web Recommendation System', *International Journal of Computer Science and Information Technologies (IJCSIT)*, 3(2), pp. 3460–3462.
- Kotkov, D., Veijalainen, J. and Wang, S. (2020) 'How does serendipity affect diversity in recommender systems? A serendipity-oriented greedy algorithm', *Computing*. Springer Vienna, 102(2), pp. 393–411.
- Koukia, S. and Rigou, M. (2006) 'The Role of Context in m-Commerce and the Personalization Dimension', in *International Conference on Web Intelligence and Intelligent Agent Technology*, pp. 1–10.
- Kovács, F., Legány, C. and Babos, A. (2005) 'Cluster Validity Measurement Techniques', in *Proceedings of the 6th International Symposium of Hungarian Researchers on Computational Intelligence*, pp. 1–11.
- Krishnaraju, V., Mathew, S. K. and Sugumaran, V. (2015) 'Web personalization for user acceptance of technology: An empirical investigation of E-government services', *Information Systems Frontiers*, March, pp. 1–17.
- Kularbphetpong, K., Somngam, S., Tongsiri, C. and Roonrakwit, P. (2014) 'A Recommender System using Collaborative Filtering and K-Mean Based on Android Application', *ournal of Theoretical & Applied Information Technology*, 70(1), pp. 161–166.
- Kumar, P. N. V. and Reddy, V. R. (2014) 'A Survey on Recommender Systems (RSS) and Its Applications', *International Journal of Innovative Research in Computer and Communication Engineering*, 2(8), pp. 5254–5260.
- Kumar, V. and Garg, M. . (2018) 'Predictive Analytics: A Review of Trends and Techniques', *International Journal of Computer Applications*, 182(1), pp. 31–37.

- Kushchu, I. and Kuscü, M. H. (2003) 'From E-government to M-government : Facing the Inevitable', in *The 3rd European conference on E-Government (ECEG03)*, pp. 235–260.
- Kuzelewska, U. (2014) 'Clustering algorithms in hybrid recommender system on MovieLens data', *Studies in Logic, Grammar and Rhetoric*, 37(50), pp. 125–139.
- Li, K. J., Zhou, Y., Shrestha, A. and Liu, G. W. (2018) 'A cluster analysis of real estate business models in China', in *Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate, 2016*, pp. 1–9.
- Liphoto, M., Du, C. and Ngwira, S. (2016) 'A Survey on Recommender Systems', in *International Conference on Advances in Computing and Communication Engineering (ICACCE)*, pp. 276–280.
- Liu, Y., Li, H., Kostakos, V., Goncalves, J., Hosio, S. and Hu, F. (2014) 'An empirical investigation of mobile government adoption in rural China: A case study in Zhejiang province', *Government Information Quarterly*. Elsevier Inc., 31(3), pp. 432–442.
- Liu, Y., Li, Q.-L., Dong, L.-Y. and Wen, B.-C. (2013) 'Combining clustering analysis methods and its application', *Journal of Applied Sciences*, 13(8), pp. 1251–1255.
- Liu, Y., Li, Z., Xiong, H., Gao, X., Wu, J. and Wu, S. (2010) 'Understanding of internal clustering validation measures', in *IEEE International Conference on Data Mining*, pp. 911–916.
- Loeb, S. and Panagos, E. (2011) 'Information filtering and personalization: Context, serendipity and group profile effects', in *2011 IEEE Consumer Communications and Networking Conference (CCNC)*. Ieee, pp. 393–398.
- Lu, J., Shambour, Q. and Zhang, G. (2009) 'Recommendation Technique-based Government-to- Business Personalized e-Services', (June), pp. 14–17.
- Lu, J., Wu, D., Mao, M., Wang, W. and Zhang, G. (2015a) 'Recommender system application developments: A survey', *Decision Support Systems*, 74, pp. 12–32.
- Lu, J., Wu, D., Mao, M., Wang, W. and Zhang, G. (2015b) 'Recommender system application developments: A survey', *Decision Support Systems*. Elsevier B.V., 74, pp. 12–32.
- Madhukar, M. (2014) 'Challenges & Limitation in Recommender Systems', *International Journal of Latest Trends in Engineering and Technology*, 4(3), pp. 138–142.

- Madhulatha, T. S. (2012) ‘an Overview on Clustering Methods’, *IOSR Journal of Engineering*, 02(04), pp. 719–725.
- Mahmood, F. M. and Abdul Salam, Z. A. (2013) ‘A conceptual framework for personalized location-based Services (LBS) tourism mobile application leveraging semantic web to enhance tourism experience’, in *Proceedings of the 2013 3rd IEEE International Advance Computing Conference, IACC 2013*, pp. 287–291.
- MAMPU (2011) *The Malaysian Public Sector ISP 2011-2015*.
- MAMPU (2018) *Implementation of national digitalisation plan in malaysia*.
- MAMPU (2021) *Pendigitalan Sektor Awam 2021-2025*.
- March, S. T. and Smith, G. F. (1995) ‘Design and natural science research on information technology’, *Decision support systems*, 15, pp. 251–266.
- Marton, A. (2013) ‘Purposive selection and evaluation criteria for qualitative research’, in *Thirty Fourth International Conference on Information Systems*, pp. 1–43.
- Mathers, N., Fox, N. and Hunn, A. (2009) *Surveys and questionnaires, The NIHR Research Design Service*.
- MCMC (2017) *Internet Users Survey 2017*. Available at: Department of Statistics Malaysia Official Portal (dosm.gov.my) [Assessed: 19 December 2018]
- MCMC (2018a) *Hand Phone Users Survey, 2018*. Available at: Department of Statistics Malaysia Official Portal (dosm.gov.my) [Assessed: 19 December 2019]
- MCMC (2018b) ‘Internet users survey 2018: Statistical brief number twenty-three’, *Internet users survey 2018*, pp. 1–39.
- Mengistu, D., Zo, H. and Rho, J. J. (2009) ‘M-Government: Opportunities and challenges to deliver mobile government services in developing countries’, *ICCIT 2009 - 4th International Conference on Computer Sciences and Convergence Information Technology*, (April), pp. 1445–1450.
- Mian, Z. and Ling, P. (2010) ‘The Tradeoff between Personalized Service and Privacy: An Empirical Analysis of 3G Adoption’, in *2010 International Conference on E-Business and E-Government*. Ieee, pp. 421–424.
- Morgan, D. L. (2014) ‘Pragmatism as a Paradigm for Social Research’, *Qualitative Inquiry*, 20(8), pp. 1045–1053.

- Muller, S., Han, S., Juell-Skielse, G. and Nilsson, A. (2014) 'Municipal Benefits of a Mobile Government Solution: A Study of the Swedish Cases', in *Proceedings of the 18th Pacific Asia Conference on Information Systems (PACIS 2014)*, pp. 1–15.
- Murata, A. and Naitoh, K. (2015) 'Multinomial Logistic Regression Model for Predicting Driver's Drowsiness Using Only Behavioral Measures', *Journal of Traffic and Transportation Engineering*, 3(2), pp. 80–90.
- Nadif, M. and Govaert, G. (2010) 'Cluster Analysis', *Data Analysis*, pp. 215–255.
- Nandi, A. and Shakoor, A. (2010) 'A GIS-based landslide susceptibility evaluation using bivariate and multivariate statistical analyses', *Engineering Geology*. Elsevier B.V., 110(1–2), pp. 11–20.
- Narvekar, M., Ravikumar, R. and Mantha, S. S. (2012) 'Personalization of Mobile Value Added Services', in *Proceedings of the CUBE International Information Technology Conference*, pp. 707–711.
- Nawrin, S. (2017) 'Exploreing K-Means with Internal Validity Indexes for Data Clustering in Traffic Management System', *International Journal of Advanced Computer Science and Applications*, 8(3), pp. 264–272.
- Nayak, M. S. D. P. and Narayan, K. A. (2019) 'Strengths and Weakness of Online Surveys', *Journal Of Humanities And Social Science (IOSR-JHSS)*, 24(5), pp. 31–38.
- Ning, A., Li, X., Wang, C., Wang, P. and Song, P. (2011) 'Research on Mobile Internet Services Personalization Principles', pp. 551–558.
- Noor, F. . and Said, M. (2021) 'The role of personal innovativeness in influencing behavioural intention to use m-Government services', *Quantum Journal of Social Sciences and Humanities*, 2(2014), pp. 90–105.
- Norusis, M. J. (2011) 'Cluster Analysis, Chapter 17', in *IBM SPSS Statistics 19 Statistical Procedures Companion*, pp. 361–391.
- OECD/ITU (2011) *M-Government-Mobile Technologies for responsive governments and connected societies, M-Government: Mobile Technologies for Responsive Governments and Connected Societies*.
- OECD (2009) *OECD e-Government Studies: Rethinking e-Government Services*.
- Olanrewaju, O. M. (2013) 'Mobile Government Framework – A Step Towards Implementation of Mobile Government in Nigeria', *International Journal of Information Science*, 3(4), pp. 89–99.

- Olmo, F. H. and Gaudioso, E. (2008) 'Evaluation of recommender systems: A new approach', *Expert Systems with Applications*, 35(3), pp. 790–804.
- Onashoga, A., Ogunjobi, A., Ibharalu, T. and Lawal, O. (2016) 'A secure framework for SMS-based service delivery in m-government using a multicast encryption scheme', *African Journal of Science, Technology, Innovation and Development*, 8(3), pp. 247–255.
- Pagare, R. and Shinde, A. (2012) 'A Study of Recommender System Techniques', *International Journal of Computer Applications*, 47(16), pp. 888–975.
- Papagelis, M., Plexousakis, D. and Kutsuras, T. (2005) *Alleviating the sparsity problem of collaborative filtering using trust inferences*, *Lecture Notes in Computer Science*.
- Peffer, K., Tuunanen, T., Rothenberger, M. A. and Chatterjee, S. (2007) 'A Design Science Research Methodology for Information Systems Research', *Journal of Management Information Systems*, 24(3), pp. 45–77.
- Petrovi, S. (2006) 'A Comparison Between the Silhouette Index and the Davies-Bouldin Index in Labelling IDS Clusters', in *The 11th Nordic Workshop on Secure IT-systems, NORDSEC 2006*, pp. 53–64.
- Pham, L. (2018) 'A Review of key paradigms: positivism, interpretivism and critical inquiry', *ResearchGate*, (4), pp. 1–7.
- Pitsilis, G., Zhang, X. and Wang, W. (2011) *Clustering Recommenders in Collaborative*, *IFIP Advances in Information and Communication Technology*.
- Polonia, G. (2013) *Analysis of sample size in consumer surveys* *Analysis of sample size in consumer surveys*.
- Progress (2017) *Personalization vs . Customization : Clarifying the Confusion*.
- Raja, S., Maher, K., Minges, M. and Surya, P. (2012) *Making Government Mobile, IC4D 2012: Maximizing Mobile*.
- Ramli, R. M. (2013) 'Hybrid Approach of e-Government on Malaysiane-Government Experience', *International Journal of Social Science and Humanity*, 2(5), pp. 366–370.
- Rana, N. P., Dwivedi, Y. K. and Williams, M. D. (2015) 'A meta-analysis of existing research on citizen adoption of e-government', *Information Systems Frontiers*, 17(3), pp. 547–563.

- Rana, N. P., Janssen, M., Sahu, G. P., Baabdullah, A. and Dwivedi, Y. K. (2019) 'Citizens' perception about M-government services: Results from an exploratory survey', in *Proceedings of the Annual Hawaii International Conference on System Sciences*, pp. 3356–3365.
- Rannu, R., Saksing, S. and Mahlakoiv, T. (2010) *Mobile Government: 2010 and Beyond*.
- Reddy, M. S. (2013) 'User Based Collaborative Filtering for Music Recommendation System Abstract', *International Journal of Innovative Research and Development*, 2(12), pp. 185–190.
- Rendon, E., Abundez, I., Arizmendi, A. and Quiroz, E. M. (2011) 'Internal versus External cluster validation indexes', *International Journal of Computers and Communications*, 5(1), pp. 27--34.
- Ricci, F. (2014) *Recommender Systems: Models and Techniques, Encyclopedia of Social Network Analysis and Mining SE - 88*.
- Rodriguez, M. Z., Comin, C. H., Casanova, D., Bruno, O. M., Amancio, D. R., Costa, L. da F. and Rodrigues, F. A. (2019) *Clustering algorithms: A comparative approach, PLoS ONE*.
- Rousseeuw, P. J. (1987) 'Silhouettes: A graphical aid to the interpretation and validation of cluster analysis', *Journal of Computational and Applied Mathematics*, 20(C), pp. 53–65.
- Saitta, S., Raphael, B. and Smith, I. (2008) 'A comprehensive validity index for clustering', *Intelligent Data Analysis*, 12(6), pp. 529–548.
- Saket, S. and Pandya, S. (2016) 'An Overview of Partitioning Algorithms in Clustering Techniques', *International Journal of Advanced Research in Computer Engineering & Technology*, 5(6), pp. 1323–2278.
- Salem, S. Ben, Naouali, S. and Sallami, M. (2017) 'Clustering Categorical Data Using the K-Means Algorithm and the Attribute 's Relative Frequency', 11(6), pp. 708–713.
- Sarstedt, M. and Mooi, E. (2014) *A Concise Guide to Market Research (Cluster Analysis)*.
- Sathiya, G. and Kavitha, P. (2014) 'An efficient enhanced k-means approach with improved initial cluster centers', *Middle - East Journal of Scientific Research*, 20(4), pp. 485–491.

- Şchiopu, D. (2010) *Applying TwoStep Cluster Analysis for Identifying Bank Customers ' Profile, Handbook of Statistical Modeling for the Social and Behavioral Sciences.*
- Schmidt, K., Stojanovic, L., Stojanovic, N. and Thomas, S. (2010) 'Semantic Technologies for E-Government', in Vitvar, T., Peristeras, V., and Tarabanis, K. (eds) *Springer. Berlin, Heidelberg: Springer Berlin Heidelberg*, pp. 261–285.
- Scholtz, J. (2004) 'Usability Evaluation User-Centered Evaluations', *Institute of Standards and Technology*, 379(1478-1-PB), pp. 1–8.
- Schroder, G., Thiele, M. and Lehner, W. (2011) 'Setting goals and choosing metrics for recommender system evaluations', in *CEUR Workshop Proceedings*, pp. 78–85.
- Shah, L., Gaudani, H. and Balani, P. (2016) 'Survey on recommendation system methods', *2nd International Conference on Electronics and Communication Systems, ICECS 2015*, 137(7), pp. 1603–1608.
- Shambour, Q., Hourani, M. and Fraihat, S. (2016) 'An Item-based Multi-Criteria Collaborative Filtering Algorithm for Personalized Recommender Systems', *International Journal of Advanced Computer Science and Applications*, 7(8), pp. 274–279.
- Shambour, Q. and Lu, J. (2010) 'A framework of hybrid recommendation system for government-to-business personalized e-services', in *ITNG2010 - 7th International Conference on Information Technology: New Generations*, pp. 592–597.
- Shani, G. and Gunawardana, A. (2011) *Evaluating Recommendation Systems, Recommender Systems Handbook.*
- Sheng, H. and Trimi, S. (2008) 'M-government: technologies, applications and challenges', *International Journal of Electronic Government*, 5(1), pp. 1–18.
- Shih, M. Y., Jheng, J. W. and Lai, L. F. (2010) 'A two-step method for clustering mixed categorical and numeric data', *Tamkang Journal of Science and Engineering*, 13(1), pp. 11–19.
- Shirkhorshidi, A. S., Aghabozorgi, S. and Ying Wah, T. (2015) 'A Comparison study on similarity and dissimilarity measures in clustering continuous data', *PLoS ONE*, 10(12), pp. 1–20.
- Showkat, N. and Parveen, H. (2017) *Quadrant-I (e-Text).*

- Shrivastava, P., Jauhari, S. and Maheshwari, D. (2014) 'M Governance : Challenges and Prospects Abstract', *International Journal of Innovative Research & Development*, 3(12), pp. 183–185.
- Shuib, L., Yadegaridehkordi, E. and Ainin, S. (2019) 'Malaysian urban poor adoption of e-government applications and their satisfaction', *Cogent Social Sciences*. Cogent, 5(1), pp. 1–18.
- Siddique, M. A. B. (2017) 'Good Governance By Mobile Phone in Bangladesh: Challenges and Way Forward', *Researchers World : Journal of Arts, Science and Commerce*, VIII(1), pp. 159–169.
- Silveira, T., Zhang, M., Lin, X., Liu, Y. and Ma, S. (2019) 'How good your recommender system is? A survey on evaluations in recommendation', *International Journal of Machine Learning and Cybernetics*. Springer Berlin Heidelberg, 10(5), pp. 813–831.
- Singh, M. (2018) *Scalability and sparsity issues in recommender datasets: a survey, Knowledge and Information Systems*. Springer London.
- Sivogolovko, E. and Novikov, B. (2012) 'Validating cluster structures in data mining tasks', in *Proceedings of the 2012 Joint EDBT/ICDT Workshops on - EDBT-ICDT '12*, pp. 245–251.
- Sorde, R. K. (2015) 'Comparative Study on Approaches of Recommendation System', 118(2), pp. 10–14.
- Sperandei, S. (2014) 'Understanding logistic regression analysis', *Biochimica Medica*, 24(1), pp. 12–18.
- Su, C. and Jing, M. (2010) 'A General Review of Mobile E-Government in China', in *2010 International Conference on Multimedia Information Networking and Security*, pp. 733–737.
- Su, X. and Khoshgoftaar, T. M. (2009) 'A Survey of Collaborative Filtering Techniques', *Advances in Artificial Intelligence*, 2009(Section 3), pp. 1–19.
- Taherdoost, H. (2016) 'Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research', *International Journal of Academic Research in Management (IJARM)*, 5(2), pp. 18–27.
- Takeda, H., Veerkamp, P., Tomiyama, T. and Yoshikawa, H. (1990) 'Modeling Design Processes', *AI Magazine*, 11(4), pp. 37–48.
- Tan, P.-N., Steinbach, M. and Kumar, V. (2005) 'Chap 8 : Cluster Analysis: Basic Concepts and Algorithms', in *Introduction to Data Mining*, p. Chapter 8.

- Thorat, P. B., Goudar, R. M. and Barve, S. (2015) ‘Survey on Collaborative Filtering and Content-Based Recommending’, *International Journal of Computer Applications*, 110(4), pp. 31–36.
- Tiihonen, J. and Felfernig, A. (2017) ‘An introduction to personalization and mass customization’, *Journal of Intelligent Information Systems*. *Journal of Intelligent Information Systems*, 49(1), pp. 1–7.
- Tkaczynski, A. (2016) *Segmentation in social marketing: Process, methods and application*, *Segmentation in Social Marketing: Process, Methods and Application*.
- Tkaczynski, A. (2017) *Segmentation Using Two-Step Cluster Analysis*.
- Torgo, L. and Ribeiro, R. (2009) *Precision and recall for regression*, *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*.
- Tossell, C. C., Kortum, P., Shepard, C., Rahmati, A. and Zhong, L. (2012) ‘An empirical analysis of smartphone personalisation: Measurement and user variability’, *Behaviour and Information Technology*, 31(10), pp. 995–1010.
- Trochim, W. M. (2007) *Research Methods Knowledge Base*.
- Trpkova, M. and Tevdovski, D. (2009) ‘Twostep cluster analysis : Segmentation of largest companies in Macedonia’, *Challenges for Analysis of the Economy, the Businesses, and Social Progress*, pp. 302–320.
- Vaishnavi, V. and Kuechler, B. (2008) ‘Theory Development in Design Science Research: Anatomy of a Research Project’, in *Third International Conference on Design Science Research in Information Systems and Technology*, pp. 1–15.
- Vargas, S. and Castells, P. (2011) ‘Rank and relevance in novelty and diversity metrics for recommender systems’, in *Proceedings of the fifth ACM conference on Recommender systems - RecSys '11*, pp. 109–116.
- Wang, C., Teo, T. S. H. and Liu, L. (2020) ‘Perceived value and continuance intention in mobile government service in China’, *Telematics and Informatics*. Elsevier Ltd, 48, pp. 1–37.
- Wang, Q., Wang, Y., Niu, R. and Peng, L. (2017) ‘Integration of information theory, K-Means cluster analysis and the logistic regression model for landslide susceptibility mapping in the three gorges area, China’, *Remote Sensing*, 9(9).

- Xu, D. J., Liao, S. S. and Li, Q. (2008) 'Combining empirical experimentation and modeling techniques: A design research approach for personalized mobile advertising applications', *Decision Support Systems*, 44(3), pp. 710–724.
- Xu, R., Xu, J. and Wunsch, D. C. (2012) 'A comparison study of validity indices on swarm-intelligence-based clustering', *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*, 42(4), pp. 1243–1256.
- Yap, C. S., Ahmad, R., Newaz, F. T. and Mason, C. (2019) 'Enhancing the use of government mobile applications: The Perspective of Citizen-initiated Contacts Theory', in *IC3K 2019 - Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, pp. 258–263.
- Yeung, K. F. and Yang, Y. (2010) 'A Proactive Personalized Mobile News Recommendation System', in *2010 Developments in E-systems Engineering*. Ieee, pp. 207–212.
- Young, T. J. (2015) *Questionnaires and Surveys, Research Methods in Intercultural Communication*.
- Yu, Y. and Zhou, Y. (2017) 'Research on recommendation system based on interest clustering', *AIP Conference Proceedings*, 1820(March 2017).
- Yuan, F., Qian, D., Huang, C., Tian, M., Xiang, Y., He, Z. and Feng, Z. (2015) 'Analysis of awareness of health knowledge among rural residents in Western China', *BMC Public Health*, 15(1), pp. 1–8.
- Yudhanegara, M. R. and Lestari, K. E. (2019) 'Clustering for multi-dimensional data set: A case study on educational data', *Journal of Physics: Conference Series*, 1280(4), pp. 1–8.
- Zakaria, M. R. (2014) 'Personalized E-Government System : Towards an Adaptive Maturity Model', *International Journal of Business Information and Technology*, 2(1), pp. 1–7.
- Zamzami, I. and Mahmud, M. (2012) 'Mobile Interface for m-Government Services: A Framework for Information Quality Evaluation', in *ACM International Conference Proceeding Series*, pp. 1–5.
- Zaoui, I., Elmaghraoui, H., Chiadmi, D. and Benhlima, L. (2014) 'Towards a Personalized E-Government Platform', *International Journal of Computer Science: Theory and Application*, 2(2), pp. 35–40.

- Zhang, J., Peng, Q., Sun, S. and Liu, C. (2014) ‘Collaborative filtering recommendation algorithm based on user preference derived from item domain features’, *Physica A: Statistical Mechanics and its Applications*. Elsevier B.V., 396, pp. 66–76.
- Zhang, S., Xi, C., Wang, Y., Zhang, W. and Chen, Y. (2013) ‘A new method for E-government procurement using collaborative filtering and Bayesian approach.’, *TheScientificWorldJournal*, 2013, p. 129123.
- Zuva, T., Ojo, S. O., Ngwira, S. M. and Zuva, K. (2012) ‘A Survey of Recommender Systems Techniques , Challenges and Evaluation Metrics’, *International Journal of Emerging Technology and Advanced Engineering*, 2(11), pp. 382–386.

LIST OF PUBLICATIONS

Journal with Impact Factor

1. **Abu Bakar, N.S.**, & Abdul Rahman, A., 2016. Personalization Strategies Implementation for Malaysian M-Government Services. *Indian Journal of Science and Technology*, 9(34), pp.1–6. <https://doi.org/10.17485/ijst/2016/v9i34/100845>. **(Q3, IF: 0.76)**
2. **Abu Bakar, N.S.**, Abdul Rahman, A. & Abdull Hamed, H.N., 2015. The Implementation of Malaysian m-Government Services. *Advanced Science Letters*, 21(5), pp.1122–1126. <https://doi.org/10.1166/asl.2015.6020>. **(Q4, IF: 0.13)**

Indexed Journal

1. **Abu Bakar, N.S.**, Rahman, A.A. & Hamed, H.A., 2017. m-Government: Benefits and its Key Attributes for Personalized Services. In *21st Pacific Asia Conference on Information Systems (PACIS 2017)*. pp. 1–13. <https://aisel.aisnet.org/pacis2017/245>. **(Indexed by SCOPUS)**
2. **Abu Bakar, N.S.**, Rahman, A.A. & Hamed, H.A., 2014. Research Approaches in Examining M-Government Services : An Investigation. *International Journal of Computer Science and Mobile Computing*, 3(11), pp.402–406.

Indexed Conference Proceedings

1. **Abu Bakar, N.S.**, Abdul Rahman, A. & Abdull Hamed, H.N., 2016. M-Government Services in Malaysia : Issues , Challenges and Better Services to Citizen. In *2016 IEEE Conference on e-learning, e-Management and e-Services (IC3e)*. pp. 116–121. <https://doi.org/10.1109/IC3e.2016.8009051>. **(Indexed by SCOPUS)**