

Advances in Intelligent Systems and Computing 1350

Jessnor Arif Mat Jizat · Ismail Mohd Khairuddin ·
Mohd Azraai Mohd Razman · Ahmad Fakhri Ab. Nasir ·
Mohamad Shaiful Abdul Karim · Abdul Aziz Jaafar ·
Lim Wei Hong · Anwar P. P. Abdul Majeed ·
Pengcheng Liu · Hyun Myung · Han-Lim Choi ·
Gian-Antonio Susto *Editors*

Advances in Robotics, Automation and Data Analytics

Selected Papers from iCITES 2020

 Springer

Advances in Intelligent Systems and Computing

Volume 1350

Series Editor

Janusz Kacprzyk, Systems Research Institute, Polish Academy of Sciences,
Warsaw, Poland

Advisory Editors

Nikhil R. Pal, Indian Statistical Institute, Kolkata, India

Rafael Bello Perez, Faculty of Mathematics, Physics and Computing,
Universidad Central de Las Villas, Santa Clara, Cuba

Emilio S. Corchado, University of Salamanca, Salamanca, Spain

Hani Hagras, School of Computer Science and Electronic Engineering,
University of Essex, Colchester, UK

László T. Kóczy, Department of Automation, Széchenyi István University,
Gyor, Hungary

Vladik Kreinovich, Department of Computer Science, University of Texas
at El Paso, El Paso, TX, USA

Chin-Teng Lin, Department of Electrical Engineering, National Chiao
Tung University, Hsinchu, Taiwan

Jie Lu, Faculty of Engineering and Information Technology,
University of Technology Sydney, Sydney, NSW, Australia

Patricia Melin, Graduate Program of Computer Science, Tijuana Institute
of Technology, Tijuana, Mexico

Nadia Nedjah, Department of Electronics Engineering, University of Rio de Janeiro,
Rio de Janeiro, Brazil

Ngoc Thanh Nguyen , Faculty of Computer Science and Management,
Wrocław University of Technology, Wrocław, Poland

Jun Wang, Department of Mechanical and Automation Engineering,
The Chinese University of Hong Kong, Shatin, Hong Kong

The series “Advances in Intelligent Systems and Computing” contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing such as: computational intelligence, soft computing including neural networks, fuzzy systems, evolutionary computing and the fusion of these paradigms, social intelligence, ambient intelligence, computational neuroscience, artificial life, virtual worlds and society, cognitive science and systems, Perception and Vision, DNA and immune based systems, self-organizing and adaptive systems, e-Learning and teaching, human-centered and human-centric computing, recommender systems, intelligent control, robotics and mechatronics including human-machine teaming, knowledge-based paradigms, learning paradigms, machine ethics, intelligent data analysis, knowledge management, intelligent agents, intelligent decision making and support, intelligent network security, trust management, interactive entertainment, Web intelligence and multimedia.

The publications within “Advances in Intelligent Systems and Computing” are primarily proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

Indexed by DBLP, EI Compendex, INSPEC, WTI Frankfurt eG, zbMATH, Japanese Science and Technology Agency (JST), SCImago.

All books published in the series are submitted for consideration in Web of Science.

More information about this series at <http://www.springer.com/series/11156>

Jessnor Arif Mat Jizat · Ismail Mohd Khairuddin ·
Mohd Azraai Mohd Razman ·
Ahmad Fakhri Ab. Nasir ·
Mohamad Shaiful Abdul Karim ·
Abdul Aziz Jaafar · Lim Wei Hong ·
Anwar P. P. Abdul Majeed ·
Pengcheng Liu · Hyun Myung ·
Han-Lim Choi · Gian-Antonio Susto
Editors

Advances in Robotics, Automation and Data Analytics

Selected Papers from iCITES 2020

Editors

Jessnor Arif Mat Jizat
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Mohd Azraai Mohd Razman
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Mohamad Shaiful Abdul Karim
College of Engineering
Universiti Malaysia Pahang
Gambang, Malaysia

Lim Wei Hong
UCSI University
Kuala Lumpur, Malaysia

Pengcheng Liu
University of York
York, UK

Han-Lim Choi
Department of Aerospace Engineering
Korea Advanced Institute of Science
and Technology
Daejeon, Korea (Republic of)

Ismail Mohd Khairuddin
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Ahmad Fakhri Ab. Nasir
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Abdul Aziz Jaafar
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Anwar P. P. Abdul Majeed
Faculty of Manufacturing and Mechatronic
Engineering Technology
Universiti Malaysia Pahang
Pekan, Malaysia

Hyun Myung
School of Electrical Engineering
Korea Advanced Institute of Science
and Technology
Daejeon, Korea (Republic of)

Gian-Antonio Susto
Department of Information Engineering
University of Padua
Padova, Italy

ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-030-70916-7 ISBN 978-3-030-70917-4 (eBook)
<https://doi.org/10.1007/978-3-030-70917-4>

© The Editor(s) (if applicable) and The Author(s), under exclusive license
to Springer Nature Switzerland AG 2021

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The International Conference on Innovative Technology, Engineering and Sciences 2020 (iCITES 2020), is the second edition of the conference series organized by Universiti Malaysia Pahang through its Alumni Society in an effort to promote key innovation in the following overarching themes and individual symposia, i.e. green and frontier materials, innovative robotics and automation, renewable and green energy, sustainable manufacturing as well as data analytics. The conference is aimed at building a platform that allows relevant stakeholders to share and discuss their latest researches, ideas and survey reports from theoretical to practical standpoint of the aforementioned fields.

ICITES2020 received more than 170 submissions. All submissions were reviewed in a single-blind manner, and the best 40 papers recommended by the reviewers are published in this volume. The editors would like to thank all the authors who submitted their papers as the papers are of good quality and represented good progress in industrial and robotic vision, motion control, autonomous mobile robots, intelligent sensors and actuators, multi-sensor fusion, deep learning and approaches and data processing.

The editors also would like to thank Assoc. Prof. Han-Lim Choi, Jamie Steel, Dr. Rabiul Muazu Musa, Dr. Miles Stopher, Assoc. Prof. Dr. Kazem Reza Kashyzadeh, Jee Kwan Ng for delivering their keynote speeches at the conference. They had to bring a new perspective on cutting-edge issues especially in the fields of robotics, automation and data analytics.

The editors hope that readers find this volume informative. We thank Springer for undertaking the publication of this volume. We also would like to thank the conference organization staff and the members of the international program committees for their hard work.

Contents

Multilanguage Speech-Based Gender Classification Using Time-Frequency Features and SVM Classifier	1
Taiba Majid Wani, Teddy Surya Gunawan, Hasmah Mansor, Syed Asif Ahmad Qadri, Ali Sophian, Eliathamby Ambikairajah, and Eko Ihsanto	
Affective Computing for Visual Emotion Recognition Using Convolutional Neural Networks	11
Arselan Ashraf, Teddy Surya Gunawan, Farah Diyana Abdul Rahman, Ali Sophian, Eliathamby Ambikairajah, Eko Ihsanto, and Mira Kartiwi	
Speech Emotion Recognition Using Deep Neural Networks on Multilingual Databases	21
Syed Asif Ahmad Qadri, Teddy Surya Gunawan, Taiba Majid Wani, Eliathamby Ambikairajah, Mira Kartiwi, and Eko Ihsanto	
Prototype Development of Graphical Pattern Security System on Raspberry Pi	31
Teddy Surya Gunawan, Fatin Nabilah Nasir, Mira Kartiwi, and Nanang Ismail	
Development of Automatic Obscene Images Filtering Using Deep Learning	39
Abdelrahman Mohamed Awad, Teddy Surya Gunawan, Mohamed Hadi Habaebi, and Nanang Ismail	
Development of Colorization of Grayscale Images Using CNN-SVM	50
Abdallah Abualola, Teddy Surya Gunawan, Mira Kartiwi, Eliathamby Ambikairajah, and Mohamed Hadi Habaebi	
Numerical Assessment of the Effects of Rooftop PVs on Ambient Air Temperature	59
Asmaa Zaz, Mohammed Ouassaid, and Mohammed Bakkali	

Sliding Mode Control of Onboard Energy Storage System for Railway Braking Energy Recovery	69
Sadiq Eziani and Mohammed Ouassaid	
Design of Inductor-Capacitor Circuits for Wireless Power Transfer for Biomedical Applications	81
Josephine Gloria Ling Ling Goh, Marwan Nafea, and Mohamed Sultan Mohamed Ali	
Perceived Risk and Benefits of Online Health Information Among Parents in Malaysia	91
Mira Kartiwi, Teddy Surya Gunawan, and Jamalludin Ab Rahman	
Wearable Textile Antenna Using Thermal-Print of Clothes Iron for the Indoor Wireless Remote Monitoring	98
Kishen Pulantran, Keerrthenan Yoorththeran, and Noorlindawaty Md. Jizat	
Smart Calling Doorbell Using GSM Module	108
N. Y. N. Shahrom and Nor Azlinah Md Lazam	
Development of Smart Home Door Lock System	118
Hazeem Ahmad Taslim, Nor Azlinah Md Lazam, and Nor Akmar Mohd Yahya	
Development of Microwave Antenna for Cancer Treatment	127
Nurfariana Mustafa, Nur Hazimah Syazana Abdul Razak, Nurhafizah Abu Talip Yusof, and Mohamad Shaiful Abdul Karim	
Review on Motor Imagery Based EEG Signal Classification for BCI Using Deep Learning Techniques	137
K. Venu and P. Natesan	
Deep Learning Techniques for Breast Cancer Diagnosis: A Systematic Review	155
B. Krishnakumar and K. Kousalya	
Hybridized Metaheuristic Search Algorithm with Modified Initialization Scheme for Global Optimization	172
Zhi Chuan Choi, Koon Meng Ang, Wei Hong Lim, Sew Sun Tiang, Chun Kit Ang, Mahmud Iwan Solihin, Mohd Rizon Mohamed Juhari, and Cher En Chow	
A Multi-stage SVM Based Diagnosis Technique for Photovoltaic PV Systems	183
Yassine Chouay and Mohammed Ouassaid	

A Framework of IoT-Enabled Vehicular Noise Intensity Monitoring System for Smart City 194
 Md. Abdur Rahim, M. M. Rahman, Md Arafatur Rahman,
 Abu Jafar Md Muzahid, and Syafiq Fauzi Kamarulzaman

16 nm FinFET Based Radiation Hardened Standard Cell Library Analysis Using Visual TCAD Tool 206
 Jessy Grace, Sphoorthy Bhushan, Chinnam S. V. Maruthi Rao,
 and Ameet Chavan

Vehicles Trajectories Analysis Using Piecewise-Segment Dynamic Time Warping (PSDTW) 214
 Muhammad Syarafi Mahmood, Uswah Khairuddin,
 and Anis Salwa Mohd Khairuddin

Real-Time KenalKayu System with YOLOv3 224
 Nenny Ruthfalydia Rosli, Uswah Khairuddin, Muhammad Faris Nor Fathi,
 Anis Salwa Mohd Khairuddin, and Azlin Ahmad

Scalp Massage Therapy According to Symptoms Based on Vietnamese Traditional Medicine 233
 Nguyen Dao Xuan Hai and Nguyen Truong Thinh

Adsorption and Artificial Neural Network Modelling of Metolachlor Removal by MIL-53(AI) Metal-Organic Framework 245
 Hamza Ahmad Isiyaka, Anita Ramli, Khairulazhar Jumbri,
 Nonni Soraya Sambudi, Zakariyya Uba Zango, and Bahrudin Saad

A Review of Digital Watermarking Techniques, Characteristics and Attacks in Text Documents 256
 Nur Alya Afikah Usop and Syifak Izhar Hisham

Auditory Evoked Potential (AEP) Based Brain-Computer Interface (BCI) Technology: A Short Review 272
 Md Nahidul Islam, Norizam Sulaiman, Bifta Sama Bari, Mamunur Rashid,
 and Mahfuzah Mustafa

Rotated TOR-5P Laplacian Iteration Path Navigation for Obstacle Avoidance in Stationary Indoor Simulation 285
 A'qilah Ahmad Dahalan and Azali Saudi

Healthy Diet Food Decision Using Rough-Chi-Squared Goodness 296
 Riswan Efendi, Dadang S. S. Sahid, Emansa H. Putra, Mustafa M. Deris,
 Nurul G. Annisa, Karina, and Indah M. Sari

Effect of Moisture Content on Crack Formation During Reflow Soldering of Ball Grid Array (BGA) Component 309
 Syed Mohamad Mardzukey Syed Mohamed Zain, Fakhrozi Che Ani,
 Mohamad Riduwan Ramli, Azman Jalar, and Maria Abu Bakar

Objective Tool for Chili Grading Using Convolutional Neural Network and Color Analysis	315
Yap Soon Hing, Wong Yee Wan, and Hermawan Nugroho	
Person Identification System for UAV	325
Bonnie Lu Sing Chen, Dik Son Cheah, Kok Wei Chan, and Hermawan Nugroho	
Artificial Neural Network Modelling for Slow Pyrolysis Process of Biochar from Banana Peels and Its Effect on O/C Ratio	336
Neoh Jia Hsiang, Anurita Selvarajoo, and Senthil Kumar Arumugasamy	
Effect of Potting Encapsulation on Crack Formation and Propagation in Electronic Package	351
Azman Jalar, Syed Mohamad Mardzukey Syed Mohamed Zain, Fakhrozi Che Ani, Mohamad Riduwan Ramli, and Maria Abu Bakar	
Novel Approach of Class Incremental Learning on Internet of Things (IoT) Framework	358
Swaraj Dube, Yee Wan Wong, Jeen Ghee Khor, and Hermawan Nugroho	
The Development of Monitoring Germination Through IoT Automated System	368
Suhaimi Puteh, Nurul Fadhilah Mohamed Rodzali, Nur Ameerah Hakimi, Nik Nurin Qistina Saiful Johar, Amirul Asyraf Abdul Manan, Nur Fatin Farisha Abdullah, and Mohd Azraai Mohd Razman	
The Diagnosis of COVID-19 Through X-Ray Images via Transfer Learning Pipeline	378
Amiir Haamzah Mohamed Ismail, Muhammad Amirul Abdullah, Ismail Mohd Khairuddin, Wan Hasbullah Mohd Isa, Mohd Azraai Mohd Razman, Jessnor Arif Mat Jizat, and Anwar P. P. Abdul Majeed	
Development of Skill Performance Test for Talent Identification in Amateur Skateboarding Sport	385
Aina Munirah Ab Rasid, Noor Aishah Kamarudin, Muhammad Amirul Abdullah, Muhammad Ar Rahim Ibrahim, Muhammad Nur Aiman Bin Shapiee, Mohd Azraai Mohd Razman, Anwar P. P. Abdul Majeed, Mohamad Razali Abdullah, and Rabi Muazu Musa	
The Diagnosis of Diabetic Retinopathy: A Transfer Learning with Support Vector Machine Approach	391
Farhan Nabil Mohd Noor, Wan Hasbullah Mohd Isa, Ismail Mohd Khairuddin, Mohd Azraai Mohd Razman, Jessnor Arif Mat Jizat, Ahmad Fakhri Ab. Nasir, Rabi Muazu Musa, and Anwar P. P. Abdul Majeed	

Gearbox Fault Diagnostics: An Examination on the Efficacy of Different Feature Extraction Techniques 399
Md Jahid Hasan, Mamunur Rashid, Ahmad Fakhri Ab. Nasir,
Muhammad Amirul Abdullah, Mohd Azraai Mohd Razman,
Rabiu Muazu Musa, and Anwar P. P. Abdul Majeed

Minimizing Normal Vehicle Forces Effect During Cornering of a Two In-Wheel Vehicle Through the Identification of Optimum Speed via Particle Swarm Optimization (PSO) 407
Nurul Afiqah Zainal, Kamil Zakwan Mohd Azmi,
Muhammad Aizzat Zakaria, and Anwar P. P. Abdul Majeed

Author Index 413

Editor Biographies

Dipl. Ing. (FH) Jessnor Arif Mat Jizat is a researcher at Innovative Manufacturing, Mechatronics & Sports Laboratory, Faculty of Manufacturing and Mechatronic Engineering Technology in Universiti Malaysia Pahang (UMP). He completed his master's degree at UMP and diploma (FH) at Hochschule Karlsruhe, Germany. His research interest includes machine learning, robotics, robotic vision and sports engineering.

Ismail Mohd Khairuddin is a lecturer at Universiti Malaysia Pahang. He received his bachelor's degree in Mechatronics Engineering from Universiti Teknikal Malaysia Melaka (UTeM) in 2010 and was awarded a master's degree in Mechatronics and Automatic Control from Universiti Teknologi Malaysia in 2012. His research interests include rehabilitation robotics, mechanical and mechatronics design, mechanisms, control and automation, bio-signal processing as well as machine learning.

Dr. Mohd Azraai Mohd Razman is a senior lecturer at Universiti Malaysia Pahang. He graduated from the University of Sheffield, UK, before he obtained his M.Eng. and Ph.D. from Universiti Malaysia Pahang (UMP) in Mechatronics Engineering. His research interest includes optimization techniques, control systems, signal processing, instrumentation in aquaculture, sports engineering as well as machine learning.

Ahmad Fakhri bin Ab. Nasir is a senior lecturer at Universiti Malaysia Pahang (UMP). He received his bachelor's degree in Information Technology from Universiti Malaya and a master's degree in Manufacturing Engineering from Universiti Malaysia Pahang. He pursued his Ph.D. at the Universiti Sultan Zainal Abidin. He has published several articles and actively doing research related to computer vision, pattern recognition, image processing, machine learning as well as parallel computing.

Mohamad Shaiful Abdul Karim received his B.Eng. (Electrical and Electronics), M. Eng. (Advanced Science and Engineering) degree and D. Eng. (Advanced Electrical, Electronic and Computer Systems) from Ritsumeikan University, Japan, in 2011, 2013 and 2016, respectively. In 2016, he joined Universiti Malaysia Pahang as a senior lecturer at College of Engineering. He is currently engaged in the research of microwave engineering, communication and biomedical medical devices.

Abdul Aziz bin Jaafar is an associate professor and researcher at the Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang. He received B.Eng (Mechanical/System) from Universiti Putra Malaysia and Ph.D. (Mechanical Engineering) from University of Bath, UK. His research interest is mainly on fluid flow and heat transfer, applications of light thin material on emergency and recreational shelters subjected to dynamic loading.

Dr. Wei Hong Lim is currently an assistant professor and a researcher at UCSI University. He obtained his B.Eng. (Hons) Mechatronic Engineering and Ph.D. in Computational Intelligence from Universiti Sains Malaysia, Penang, Malaysia. He was attached to the Intelligent Control Laboratory in National Taipei University of Technology, Taiwan, as the postdoctoral researcher from 2015 to 2017 and as the visiting researcher in 2019.

Anwar P. P. Abdul Majeed graduated with a first-class honours bachelor's degree from Universiti Teknologi MARA (UiTM), Malaysia. He obtained his master's degree Imperial College London, UK, before receiving his Ph.D. from Universiti Malaysia Pahang (UMP). He is a chartered engineer (C.Eng.) at the Institution of Mechanical Engineering (IMechE), UK.

Pengcheng Liu received the B.Eng. degree in measurement and control, the M.Sc. degree in control theory and control engineering from the Zhongyuan University of Technology, China, and the Ph.D. degree in robotics and control from Bournemouth University, UK. He is currently a lecturer (Tenured Assistant Professor) at the Department of Computer Science, University of York, UK. He is an associate editor of IEEE Access, and he received the Global Peer Review Awards from Web of Science in 2019 and the Outstanding Contribution Awards from Elsevier in 2017.

Prof. Hyun Myung received the B.S., M.S. and PhD degrees in electrical engineering from the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea. Since 2008, he has been a professor at the Department of Civil and Environmental Engineering, KAIST, and he is the head of the KAIST Robotics Program. From 2019, he is a professor at the School of Electrical Engineering. He led the development of the world-first robots such as jellyfish removal robot (JEROS) and CAROS (wall-climbing drones).

Han-Lim Choi received his M.S. in Aerospace Engineering from the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, in 2020. He then pursued his PhD in Aeronautics and Astronautics, Massachusetts Institute of Technology (MIT), USA. He is currently serving as an associate professor at the Department of Aerospace Engineering, KAIST, Daejeon. His research interest includes information-theoretic decision-making for cyber-physical systems, planning and control for multi-agent systems, air and space vehicle guidance and control as well as environmental sensing systems.

Dr. Gian Antonio Susto received the M.S. degree in control systems engineering and the Ph.D. degree in information engineering from the University of Padova, Italy, in 2009 and 2013, respectively. He is currently an assistant professor at the University of Padova and a chief data scientist and founder at Statwolf Limited, Dublin, Ireland. His research interests include manufacturing data analytics, machine learning, gesture recognition and partial differential equations control.

Prototype Development of Graphical Pattern Security System on Raspberry Pi

Teddy Surya Gunawan^{1,2}[0000-0003-3345-4669], Fatin Nabilah Nasir¹,
Mira Kartiwi³, Nanang Ismail⁴

¹ Electrical and Computer Engineering Department, International Islamic University Malaysia

² School of Electrical Engineering & Telecommunications, UNSW, Australia

³ Information Systems Department, International Islamic University Malaysia

⁴ Electrical Engineering Department, UIN Sunan Gunung Djati, Bandung, Indonesia
tsgunawan@iium.edu.my

Abstract. Password is a primary security mechanism that consists of a secret phrase created using alphabetic, numeric, alphanumeric, and symbolic characters, or a combination. It is used to restrict access to a system, application, or service to only those users who have the authorization to use the system or device. Because of increased computing power, modern passwords must be very long and complicated, which will make them hard to remember. Some research studies show that it is easier for people to remember visual passwords instead of textual ones. Therefore, this research aims to enhance the authentication process's security using the graphical pattern unlock approach on Raspberry Pi. The grid size of 5×5 was selected in the implementation, as it provides the tradeoff between security strength and an easy pattern to remember. The proposed system could be connected to the smart home system, which can enhance their security. Prototype validation revealed that the prototype is working as intended, and the authentication process took around 1.2 seconds to complete.

Keywords: smart home, security enhancement, graphical pattern, Raspberry Pi.

1 Introduction

Nowadays, passwords hold a crucial role in our society as they are implemented in many different confidential situations. The passwords have been derived into various approaches like Personal Identification Number (PIN) codes, fingerprints, pattern locks, and passwords with the common goal to protect users' private information. Due to the numerous amounts of sensitive data stored on the devices, the need for security increases, which leads to the authentication process as an essential topic for research. Screen pattern locks are used as a protection mechanism to avoid sensitive information leakage from any device [1].

The graphic pattern is one of the examples of a graphical password mechanism used for an authentication process. A graphic pattern is a pattern that needs to be connected at least four contact points without lifting and avoiding any intermediate points [2]. The pattern itself is in various grid size patterns as 3×3 size with nine nodes inter-

face is commonly used in the different authentication process, i.e., the smartphone's graphical pattern. In [3], if the number of connected nodes must be at least four points, and each node can be touched only once, then the possible pattern is around 38911.

As stated by [4], the length and complexity of one text-based password determine how secure the code is, yet humans have difficulties recalling them. Users tend to select simpler passwords in terms of length, which are in the weak password category, without considering their security. It is also easier for users to remember a graphical approach than a text-based approach like PIN passwords, as described in [5].

One method to improve the security strength of a graphical pattern is by expanding the grid size or increasing the number of contact points [6], using embedded pattern strength [7], changing pattern layout arrangement [5], multi-layered drawing [8], rotation [9], or use a strength meter [10]. Many kinds of research have been conducted on improving the strength of a graphical pattern on a smartphone. However, not much of the research focused on improving a smart home system's security, like [11, 12]. Therefore, this paper aims to develop a fast and accurate graphics pattern recognition system implemented on Raspberry Pi. The target is to be able to validate and authenticate a user within 1 second processing time. Our proposed system's primary input device is an LCD touchscreen that functions as both the input and output at the same time. Moreover, the primary output device is the magnetic lock, which is controlled by Raspberry Pi.

2 Design of Graphical Pattern Security System

2.1 Hardware Design

Raspberry Pi is a single-board computer that can run various operating systems, either Linux or non-Linux based [13]. Examples of Linux-based operating systems are Raspbian, which is the most recommended operating system for Raspberry Pi, Android Things, an embedded version of the Android operating system, and Arch Linux ARM. Meanwhile, an example of non-Linux based operating systems is Windows 10 IoT Core, HelenOS, RISC OS Pi, and Haiku.

Fig. 1 shows the proposed block diagram of the graphical pattern security system using Raspberry Pi. The Raspberry Pi is connected to the LCD touchscreen, which is shown in Fig. 2. Raspberry Pi 3 has a quad-core processor, 1 GB RAM, dan built-in graphics [13]. The relay circuit is connected to Raspberry Pi and provides an interface to the high voltage magnetic lock. The status could be shown using LED indicators or further send messages using an internet connection or as part of a smart home system. Finally, the overall power required, including magnetic lock, is less than 3 A, so that a compact power supply, i.e., a smartphone charger, could be used as the power supply. The LCD touch screen has the function as output as well as input.

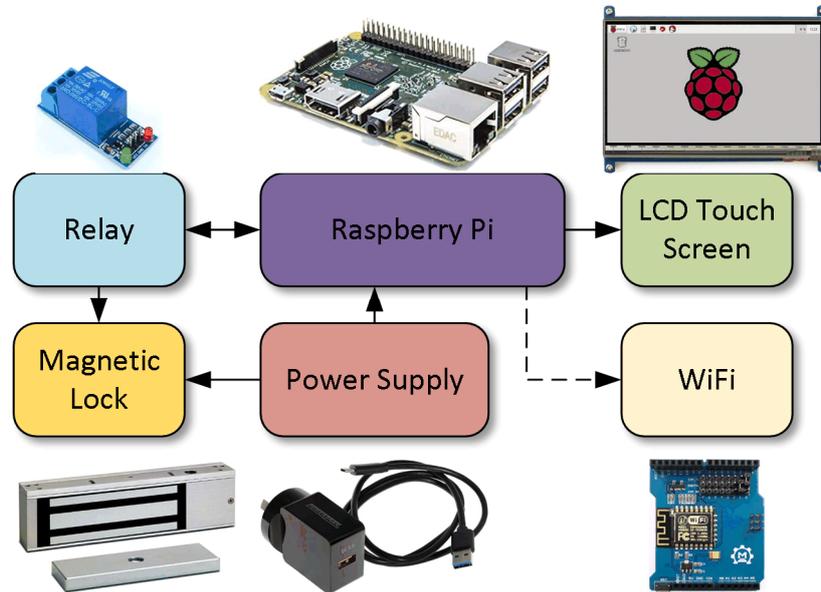


Fig. 1. Block Diagram of the Proposed Hardware

2.2 Software Design

Microsoft Visual Studio is an integrated development environment (IDE) used to develop programs and applications such as web applications and mobile applications. It uses Microsoft software development platforms, i.e., Windows API and Windows Forms. It supports different kinds of programming languages, and it allows users to edit and debug the code. Few examples of built-in language available include C, C#, Visual Basic, .Net, and JavaScript. After developing the program in Visual Studio, it needs to be copied into and run on Raspberry Pi 3. First, the mono repository package needs to be added to the system. As Raspbian Stretch is chosen to be installed for this research; thus, the package repository for Raspbian is added.

There are three central graphical security systems, including feature extraction, classifier, and training database. During the feature extraction phase, the system will extract the input pattern's behavior, i.e., the starting and ending node chosen by the user, the length of the pattern, and the distance between each selected node. Then, the classifier categorizes the complexity of the pattern based on the pattern behavior. The classifier is also used to compare the input pattern with the enrolled pattern in the database. Based on the flow process between the classifier and the database, if the input pattern matches the database's enrolled pattern, the system will send feedback to the decision rule.

Fig. 2 shows the flowchart of user registration, database creation, and login verification. In this research, the graphical approach used to develop the pattern layout is the expanded grid size approach proposed by [6]. The pattern layout is created in a 5×5 grid size.

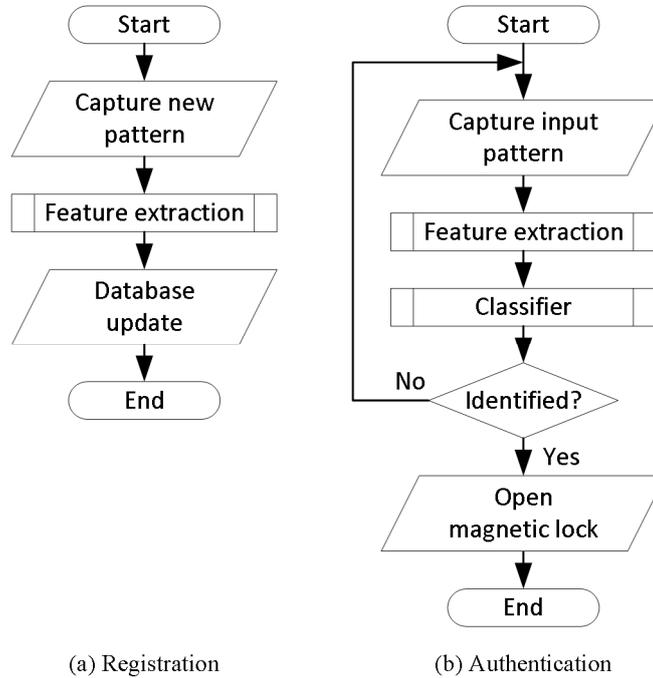


Fig. 2. System Flowchart for Registration and Authentication

3 Implementation

After the codes have been compiled in the Visual Studio, the executable file must be copied into the Raspberry Pi 3. Then, the Mono repository needs to be added to the system. The mono-devel package also needs to be installed in the code compilation system, as shown in Table 1.

Table 1. Installation of Mono Repository on Raspberry Pi 3

1	<code>sudo apt install apt-transport-https dirmngr</code>
2	<code>sudo apt-key adv --keyserver hkp://keyserver.ubuntu.com:80 --recv-keys 3FA7E0328081BFF6A14DA29AA6A19B38D3D831EF</code> <code>echo "deb https://download.mono-project.com/repo/debian stable-raspbianstretch main" sudo tee /etc/apt/sources.list.d/mono-official-stable.list</code>
3	<code>sudo apt update</code>
4	<code>sudo apt install mono-devel</code>

A prototype is needed to test the coding and evaluate the design. The process involved is including software development, which is done by using Microsoft Visual Studio, and hardware development, which uses Raspberry Pi 3 and its components.

C# language is used to code all the instructions, programs, and graphical user interface (GUI).

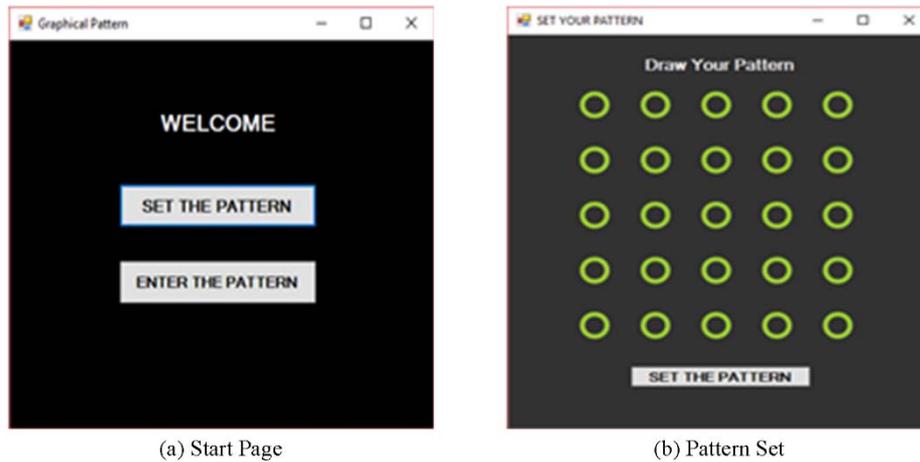


Fig. 3. GUI Design for Start Page and Pattern Set Functions

Fig. 3 shows the user interface of the Start Page and Pattern Set functions. The layout pattern is created in the bigger size, i.e., 5×5 grid size. The pattern layout is created in a bigger size as it is one of the security enhancement approaches. As the pattern grid size increases, the number of possible patterns also increases. Hence, there would be a high possibility of the complexity of user-chosen patterns to increase. Some functions have been set on the lock screen pattern to help the user draw a better pattern. For instance, the user cannot create the closed-loop pattern, i.e., the node cannot be contacted more than once.

Moreover, the user is allowed to reverse the gesture while drawing the pattern. This function helps the user to create a better pattern with a better complexity. The coordinates of each node are saved as they will be used during the authentication process. The coordinates of the saved pattern are compared with the coordinates of the inputted pattern.

Fig. 4(a) shows the user interface of the Pattern Input function. During the authentication process, the user authenticates the input pattern with the pattern that has been created earlier. The coordinates of the inputted pattern are recorded and compared with the saved pattern. Next, the Valid Pattern message will be displayed if the coordinates of both patterns match, as shown in Fig. 4(b). Otherwise, the Invalid Pattern message will be displayed, as shown in Fig. 4(c).



Fig. 4. GUI Design for Pattern Input, Valid, and Invalid Pattern Input

4 Prototype Validation

Fig. 5 (a) and (b) shows the actual Start Page and user interface of the Pattern Input function. It is the actual implementation of Fig. 3, previously. Pattern Input will capture and validate the user's graphical pattern password. Several evaluations have been conducted in this phase, in which we found that there is no lagging experienced by the user. The authentication time to authenticate registered users is 1.2 seconds on average when tested in 10 experiments.

Fig. 5 (c) and (d) shows the actual valid and invalid pattern message. It is the actual implementation of Fig. 4, previously. The system will validate the entered pattern to be checked with the database's registered user's pattern. If it is the correct pattern, it will open the magnetic lock. While if it is incorrect, it will provide the user with three more attempts before it triggers the alarm.

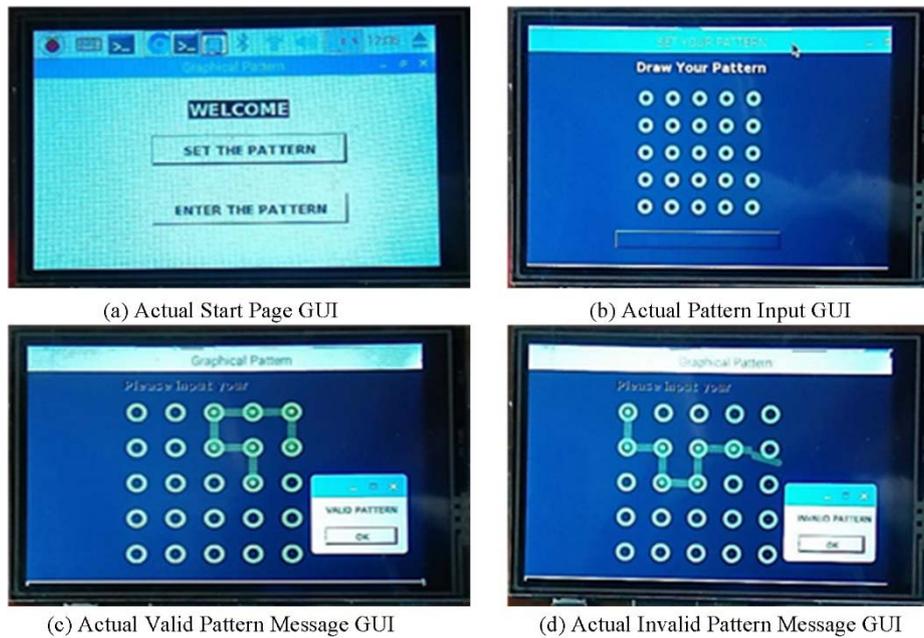


Fig. 5. Actual Prototype GUI

5 Conclusions and Future Works

This paper has presented the development of a graphical pattern security system on Raspberry Pi. First, the hardware and software requirements have been designed so that it can fulfill the specifications. Next, a 5×5 pattern grid was implemented in Raspberry Pi using C#. Results showed that our proposed prototype works as intended with an authentication time around 1.2 seconds on average. Further research can be conducted, including implementation with various pattern grid size, implementation of pattern strength meter, and integration with the smart home system.

Acknowledgments

The authors would like to express their gratitude to the Malaysian Ministry of Education (MOE), which has provided research funding through the Fundamental Research Grant, FRGS19-076-0684 (FRGS/1/2018/ICT02/UIAM/02/4). The authors would like to acknowledge support from International Islamic University, University of New South Wales, and Universitas Mercu Buana.

References

1. Li, Q., P. Dong, and J. Zheng, *Enhancing the Security of Pattern Unlock with Surface EMG-Based Biometrics*. Applied Sciences, 2020. **10**(2): p. 541.
2. Aviv, A.J., et al., *Smudge attacks on smartphone touch screens*. Woot, 2010. **10**: p. 1-7.
3. Løge, M.D., *Tell me who you are and i will tell you your unlock pattern*. 2015, NTNU.
4. De Angeli, A., et al., *Is a picture really worth a thousand words? Exploring the feasibility of graphical authentication systems*. International journal of human-computer studies, 2005. **63**(1-2): p. 128-152.
5. Uellenbeck, S., et al. *Quantifying the security of graphical passwords: the case of android unlock patterns*. in *Proceedings of the 2013 ACM SIGSAC conference on Computer & communications security*. 2013.
6. Aviv, A.J., R. Kuber, and D. Budzitowski, *Is Bigger Better When It Comes to Android Graphical Pattern Unlock?* IEEE Internet Computing, 2017. **21**(6): p. 46-51.
7. Siadati, H., et al., *Fortifying android patterns using persuasive security framework*. UBICOMM 2015, 2015: p. 81.
8. Chiang, H.-Y. and S. Chiasson. *Improving user authentication on mobile devices: a touchscreen graphical password*. in *Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services*. 2013.
9. Chakrabarti, S., G.V. Landon, and M. Singhal. *Graphical passwords: drawing a secret with rotation as a new degree of freedom*. in *Proceedings of the Fourth IASTED Asian Conference on Communication Systems and Networks*. 2007. Citeseer.
10. Sun, C., Y. Wang, and J. Zheng, *Dissecting pattern unlock: The effect of pattern strength meter on pattern selection*. Journal of Information Security and Applications, 2014. **19**(4-5): p. 308-320.
11. Gunawan, T.S., et al., *Prototype design of smart home system using internet of things*. Indonesian Journal of Electrical Engineering and Computer Science, 2017. **7**(1): p. 107-115.
12. Gunawan, T.S., et al., *Performance evaluation of smart home system using internet of things*. International Journal of Electrical and Computer Engineering, 2018. **8**(1): p. 400.
13. Gunawan, T.S., et al., *development of face recognition on raspberry pi for security enhancement of smart home system*. Indonesian Journal of Electrical Engineering and Informatics (IJEEI), 2017. **5**(4): p. 317-325.