Lecture Notes in Operations Research

Ali Emrouznejad · Panagiotis D. Zervopoulos · Ilhan Ozturk · Dima Jamali · John Rice *Editors*

Business Analytics and Decision Making in Practice

Proceedings of the International Conference on Business Analytics in Practice (ICBAP 2024), Sharjah, UAE

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Preface

In a business context where success or failure is increasingly determined by effective business analytics, the integration of data into current decision-making models has become a vital driver of sustainable growth, innovation, efficiency, and competitive advantage. Harnessing the power of data, business analytics allows organizations to generate actionable insights, identify emergent trends, and better anticipate future contextual changes. In this book, *Business Analytics and Decision Making in Practice*, we seek to investigate some practical applications of these analytical methodologies by offering readers a sample of papers that navigate illustrate the use of Business Analytics in real-world organizations and operational scenarios. Using both novel theoretical frameworks and examples from real-world practice, provides managers and researchers the tools and insights necessary to begin to unlock the potential of data-driven decision-making.

The papers in this volume were submitted at the International Conference on Business Analytics in Practice (ICBAP) 2024, held at the University of Sharjah in the UAE in 2024. Hosted in collaboration by leading institutions including the College of Business Administration at the University of Sharjah, UAE, and the Centre for Business Analytics in Practice at Surrey Business School in the University of Surrey, UK, the conference was the site of a vibrant exchange of theory, practical insights and innovative thinking for those in attendance.

The conference program included papers within the business analytics, decision support systems, and sustainability analytics fields. Recurrent themes included the interplay of institutional factors and environmental sustainability issues, in different national contexts. The construction industry is also featured in a number of papers, both in terms of sustainability and worker safety. Data envelopment analysis was employed in various contexts, with extensions to this method a highlight of a number of papers. Cutting-edge applications of machine learning were also presented, especially in financial analytics and portfolio management. At the individual level, the influence of personality traits on organizational behavior was explored in a number of submissions. Finally, novel papers were presented exploring digital supply chain logistics, the application of AI in preserving food supply chains, and the effects of circular economy practices on firm performance.

This volume comprises 29 chapters that offer a cross-section of novel applications of business analytics to real-world challenges. From the use of the Internet of Things (IoT) in the hospitality industry to the detection of anomalies in enterprise payment systems through the use of machine learning techniques, each paper provides novel conceptual ideas and applied data to illustrate practical implications of these new techniques. The book will be of interest to anyone seeking to leverage data-driven approaches to improve business and public sector performance.

We extend our appreciation to all the authors whose contributions have made this volume possible. In addition, we thank the reviewers whose feedback and constructive recommendations have enhanced the quality and rigor of each chapter. We would also like to express special thanks to Springer publisher and Springer Production, especially Dr. Christian Rauscher (Editorial Director at Springer) and Ms. Jialin Yan (Springer Editor), who supported the publication of this volume in the Springer series of Lecture Notes in Operational Research.

Finally, it is essential to clarify that the responsibility for the content, accuracy, and interpretations presented in each chapter lies solely with the respective authors. As editors, we facilitate the compilation and organization of the material, but we do not assume any responsibility for errors, inaccuracies, or omissions that may be present within individual chapters. While every effort has been made to ensure the quality and integrity of the content, readers should exercise their judgment and discretion when interpreting and utilizing the information provided.

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Chapter 1
Internet of Things (IoT) a Trending Technology: Transforms the Hospitality Industry. Case Study: W Costa Navarino (Messinia, Greece)

Nikoletta Klada and Nikolaos Georgopoulos

Abstract The main study of this research is the Internet of Things (IoT) and the vital application in the Hospitality Industry. The methodology that has been used in this paper is based on literature review, which tries to find the gap in the international literature and understand the concepts which are under examination. The world community have tried to define the term "Internet of Things (IoT)", although its initial use has been attributed to Kevin Ashton, an expert on digital innovation. He is known for coining the term "The Internet of Things". Tourism is one of the economic sectors in which the rise of Internet of Things (IoT) applications is expected to greatly boost development. The Internet of Things (IoT) has the potential to transform the Hospitality Industry. Internet of Things (IoT) will help hotel owners, managers and others in Tourism Sector to understand the potential that this trending technology holds. IoT is already being applied in the hospitality industry and the future potential it has for hotel owners and managers makes it necessary for them to understand and use IoT. The survey was held in Costa Navarino (Messinia, Greece), in order to determine how important and efficient is for a hotel to use Internet of Things technology. The IoT is an integral part of tourism sector and W Costa Navarino is using IoT to automate every possible service for improving guest experience.

Keywords Internet of Things (IoT) · Hospitality industry · Tourism

Introduction

In an effort to find a unique definition for Internet of Things (IoT) it is generally accepted by academics, researchers, practitioners and innovators that there isn't one. Overall, what all of the definitions have in common is the idea that the first version

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of the Internet was about data created by people, while the next version is about data created by things.

The term "Internet of Things" was first used by Kevin Ashton in 1999. IoT is a network that can connect with anything anytime and anyplace by technologies of RFID (Radio Frequency IDentification), WSN (Wireless Sensor Network) and 3G/4G/5G mobile communication, according to an agreed protocol, in order to identify, locate, track, monitor and manage smart objects [10].

The potential of the Internet of Things market is huge, where "things" interacting with each other act as active participants in the business [5]. Objects connected to the global Internet contribute both to improving the quality of life of the population and influence the processes taking place in the surrounding world. Such interconnection of devices in a single network brings huge opportunities, opening up new and broader prospects in the field of management, analytics, and security [14].

Literature Review

The basic concept of literature review is to understand the main topics and theories associated with the phenomenon, the trending Technology, Internet of Things (IoT). Some definitions of Internet of Things will be presented below, started with the most recent one.

"The Internet of Things (IoT) is defined as a paradigm in which objects equipped with sensors, actuators, and processors communicate with each other to serve a meaningful purpose [12]". U's Telecommunication Standardization Sector (ITU-T) defines IoT as "A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies."

IoT is an "Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications" [4].

Nunberg [11] considers that the Internet of Things is a novel paradigm shift in IT arena. The phrase "Internet of Things" which is also shortly well-known as IoT is coined from the two words i.e. the first word is "Internet" and the second word is "Things". The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies.

The Internet of Things can also be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object [1].

Internet of Things is maturing and continues to be the latest, most hyped concept in the IT world. Over the last decade the term Internet of Things (IoT) has attracted

attention by projecting the vision of a global infrastructure of networked physical objects, enabling anytime, anyplace connectivity for anything and not only for any one [8].

"Internet of Things can also be realized in three paradigms—internet—oriented (middleware), things oriented (sensors) and semantic- oriented (knowledge)" [2].

According to Kranenburg [9] "Internet of Thing is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "Things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network".

Internet of Things: Application in the Hospitality Industry via Solutions/Examples

The Hospitality Industry consists of multiple stakeholders and impacts global economy. New disruptive technologies, such as Internet of Things (IoT), Artificial Intelligence (AI), Robots, Social Media and others are crucial to achieving more efficiency and productivity in Hospitality Industry.

IoT is used in many different areas to improve efficiency and provide a better customer experience. Homes are increasingly turning into smart homes and beginning to give way to smart hotels, bringing hoteliers an opportunity to better serve guests, offer value-added services, and run the facility on the back end with far greater efficiency than was ever before possible [3].

Innovations in smart devices and IoT are driving the reform of technology used in the hospitality service platform [7]. The hotel industry can use IoT to provide integrated services such as application-driven devices and automated triggers like automated door locks, set-top-boxes, thermostats, telephones, light switches, voice-based interaction, electric blinds and other devices that are connected on a common network to enable the services that guests want. These kinds of facilities will make the guest experience more personalized and speedier, and the hotelier, more efficient. Also, hotels will be able to deliver more value to their guests at lower costs [3].

Table 1.1 illustrates several solutions and examples of IoT in the Hospitality Industry.

IoT is already being applied in the hospitality industry and the future potential it has for hotel owners makes it important for them to understand and use IoT. In addition, it can help to automate processes, improve the guest experience and help hospitality companies to save money on energy costs and maintenance. To come to closer terms with their present and future guests, hotels need to continuously monitor trends on the ever more discerning and burgeoning tourism market and adapt to the development of new technologies to remain competitive [3].

In the hospitality industry IoT applications should be embraced among businesses, and building this platform is necessary for innovators hotel owners and managers.

Table 1.1 Several solutions of IoT in the hospitality industry

Solution	Application/Example
Personalised hotel rooms	Hilton and Marriott have experimented with slightly different takes on the 'connected room' concept, where users are able to control many of the room's features from their mobile phone, or from a provided, tablet. In addition, IoT platforms could over time memorize a guest's specific comfort preferences, such as temperature, lights, TV channels & shades, and automatically set up the room for their next stay. Hotels can automatically send electronic key cards to guests' smartphones, allowing them to check-in without anyone's assistance
Voice-based interaction	*Amazon Alexa* enables the guest to use voice-control on different smart home devices. It's basically a guest's personal butler who never gets tired of fulfilling their needs. Alexa can be configured by hospitality providers to allow guests to control and adjust in-room devices such as lights, thermostats, blinds and TVs
Integration with mobile	*Fast check-in:* Starwood and Hilton, for example, already offer an option of checking in via a mobile gadget instead of spending time at the front desk. *Control device*: all thee functions performed by quite a few remote controls, key cards and switches are now available at the click of a button on a mobile device
Body area sensors	*Wireless medical sensor* technology further expands the scope of date collection by providing detailed data about organs and system within the body. For example, service providers can filter out high carbohydrate and sugary meal options for diabetic guests, high cholesterol meal options for patients with heart disease, etc.
Inventory management	IoT will change the way hotels manage their inventories. IoT implemented systems will keep record of the inventory and manage the changes in them automatically
Location-based information	For example, sending SMS messages about menu items at the restaurant when guests are close by or advertising gym services when they are near the gym. It may also mean sending up-to-date information about local transport link, or nearby attractions…
Flic—a wireless button	For example, when someone calls reception to ask for more towels or coffee. With *Flic*, guests could notify housekeepers about it with a press of a button. Ordering services and sending automated messages has never been this easy
Building automation and monitoring	For example, in-room monitoring system can be used to detect whether a room is occupied or unoccupied so as to schedule housekeeping services
Valpas—autonomous bed bug prevention	"Valpas has developed an autonomous bed bug prevention system that allows guests to stay carefree from bed bug anxiety at exciting hotels around the world. By replacing their existing bed legs with Valpas' smart legs, hotels can monitor the rooms in real-time and receive notifications of eliminated bed bugs caught inside the legs"

(continued)

Table 1.1 (continued)

Solution	Application/Example
Automation	IoT automates the business functions of travel and hotel businesses. For example, hotels can track supply chains more efficiently through sensors in shipments, enabling the to get ready for any future contingency and avoid service disruptions to guests
Augmented reality and beacon technology	For example, this technology can be used to provide guests with services such as digitally guided tours, previews of in-room environment (e.g., décor, facilities and amenities, etc.), immediate translation services for signs and other written materials, interactive restaurant menus with dish previews, critic reviews, food allergy information, etc.
Maintenance	By installing sensors, hotels can track the condition of all electronic devices and schedule the work of personnel according to whether the guest is in or out of the room. In addition, predictive maintenance will take hoteliers one-step further; it will use sensors to recognize the problems and alert before the issue hazardous
Energy saving	While IoT can enable personalization, it can also offer businesses financial benefits through automated or smart energy saving

Source Car et al. [3]

Case Study W Costa Navarino

Founded in 1997, TEMES is a leading investor, developer and operator in the high-end tourism and real estate sector in Greece. Costa Navarino, its flagship development, is one of the largest tourism investments in the Mediterranean. Based on solid financial foundations, the development will ultimately comprise four (4) resort areas with 5-star hotels, quality facilities and world-class golf courses. TEMES has fulfilled the vision of its founder, Captain Vassilis Constantakopoulos, to establish his homeland Messinia as a top international destination.

Costa Navarino is a sustainably driven destination in the Mediterranean, located in the Greek region of Messinia in the southwest Peloponnese. One of the most unspoiled and breathtaking seaside landscapes, this is a region shaped by 4,500 years of history. The Costa Navarino philosophy is driven by a genuine desire to preserve the natural beauty and heritage of Messinia.

With a total of four luxury resorts (Table 1.2), four signature golf courses, private residences, more than 40 dining and entertainment venues, and an abundance of sports and entertainment experiences across its sites, Costa Navarino has established Messinia as a place to visit as well as to live.

In this paper we will present W Costa Navarino Resort as an example, which provides the Technology IoT in many different areas, in order to improve efficiency and provide a better customer experience.

Table 1.2 Costa Navarino capacity

	Brands	Resort	Rooms
1	The luxury collection	Romanos resort	321
2	Westin	The Westin resort Costa Navarino	445
3	W hotels	W Costa Navarino	246
4	Mandarin	Mandarin oriental, Costa Navarino	99
		Total No Rooms	**1111**

W Costa Navarino marks the debut of W Hotels in Greece. This new resort opened in August 2022. Vivid and bright, with a distinctive design inspired by the region's architecture, W Costa Navarino shows 246 stylish rooms (www.costanavarino.com).

Applications of Internet of Things in W Costa Navarino

Costa Navarino invests significantly in research and development with respect to their guests' changing needs in areas such as nutrition, wellbeing, fitness and technology.

Since 2017, Costa Navarino's hotels have been using the **Marriott Guest Voice platform** to collect feedback via online Guest Satisfaction Surveys (GSS) sent to guests after their stay at Costa Navarino. In addition to the online surveys, a dedicated team monitors social media and relevant websites, collecting feedback and responding to guest inquiries in real time. The cornerstone of their philosophy is to handle any guest enquiry or request in less than 24 h. The combined analysis of the information collected covers the entire guest experience from arrival to departure, assessing the quality of activities and services, from housekeeping and staff attitude, to pools and fitness centers, Spa, golf courses, bars & restaurants, lobbies, shops, kid's facilities and all other guest areas. The use of Key Performance Indicators provides a credible and quantifiable assessment of how well they meet guests' expectations, together with valuable insights into how to make their services even better.

The Costa Navarino Mobile application (10 + thousand downloads—Google store) is a one-stop guide to plan a next visit to the destination.

The guest can use the Costa Navarino App to:

- Explore the destination and its full offering.
- Locate his room & all facilities within the map.
- Discover events and activities that are happening daily in our Calendar.
- Browse the menus of our restaurants and make dinner reservations.
- Discover the Navarino Agora, a bustling new open marketplace, with retail outlets, dining venues & pop-up events.
- Select among various sports, indoor and outdoor activities.
- Book Spa & Wellness treatments to relax and unwind.
- Order in-room dining, book a transfer or contact Costa Navarino Concierge.

Table 1.3 Marriott Bonvoy App

	Marriott Bonvoy App	W Costa Navarino
1	Mobile check in/Mobile key	
2	Manage marriot account	✓
3	Mobile chat and requests	✓
4	Hotel booking	✓
5	Mobile dining	✓
6	Shuttle services/shuttle tracker	✓

Another platform technology which Costa Navarino uses, is **Marriott Bonvoy Application** (10 + million downloads—Google store), as it is shown in Table 1.3. Marriott Bonvoy Application provides features as:

1. Mobile Check-In. The guest is able to use Mobile Check-In, when he opens the app, then selects "check in" and then sets his estimated arrival time and confirm the check-in by hitting the button on the bottom of the screen. Due to the Greek Government this feature is not allowed. Upon arrival the guest must give a passport and sign the registration form in the Reception area.
2. Manage Marriot account: the guest is able to view stay history, earn and redeem points as a Marriot Member.
3. Via Mobile chat Mobile Requests, the guest is able to:
   - Customize the room with extra blankets or pillows
   - Request services like housekeeping and luggage assistance (valet)
   - Choose a list of amenities (towel, shampoo, toothbrush, etc.).
4. Hotel booking: the guest browses, books a hotel and manages a new booking.
5. Mobile Dining: the guest can browse the hotel menu and order food and drinks.
6. Shuttle services: the guest can order a shuttle service and see the location of the hotel shuttle in real time with shuttle tracker.

Triparound's platform: is making success accessible for any travel business worldwide. Maximizing guest spending and offering personalized service. Triparound's concierge software works as an all-in-one central hub for hotels and resorts to add, manage and promote all in-house and third-party experiences (like trips, excursions, book outdoor activities, etc.).

The KNX installation: The Guest Room Management System (GRMS) shall be programmed to provide lighting and shading for the individual guest room with the possibility of future upgrades.

The system shall include, but shall not be limited to, the following for each guest room:

Room control devices and system components
Outside courtesy indicator panel
Energy saver card holder
Room call system in rooms for disabled guests (optional)
Centralized monitoring/control and interfaces.

LG application in A/C: There are different ways to optimize air conditioning in W Costa Navarino. Air conditioning and heating control must be carried out both in common areas such as lobby, living rooms, restaurants, reception, bathrooms, as well as in private areas like guest rooms.

At the air conditioning level, limiting the setpoint temperatures in public areas such as main rooms or large rooms can be very useful. It is also important to limit the setpoint temperatures to prevent hotel visitors from misusing the air conditioning system in their rooms, which otherwise leads to overconsumption.

By using monitoring and control systems for optimization of energy consumption, immediate value can be obtained. Management of consumption and real time energy control allows for identification and resolution of unnecessary energy usage. Current control systems allow monitoring of a large number of variables including for example: setpoint temperature, open window, occupancy and scenes.

Conclusions

Nunberg [11] considers that the Internet of Things is a novel paradigm shift in IT arena. The phrase "Internet of Things" which is also shortly well-known as IoT is coined from the two words i.e.the first word is "Internet" and the second word is "Things". The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies.

Internet of Things (IoT) can tremendously revolutionize the hospitality industry. With IoT for hospitality industry, hotel owners, managers and others in tourism can increase guest satisfaction and overall productivity. Thanks to The Internet of Things (IoT) an essential opportunity is presented to the hospitality industry to reduce operational costs.

The boom in IoT Technology will boost the future of the hospitality industry; it will provide a competitive edge in the market and through the interconnection of devices, (sensors, actuators, identification tags, mobile, etc.) through the internet. IoT is no longer just a concept, it is very much a part of the industry and statistics are growing because IoT enables processes, data, and outcomes [13].

As the Fourth Industrial Revolution continues to run its course—especially with technologies such as IoT, which have an endless array of applications—now is the best time for a hotel owner or a manager to be an innovator. Very soon applications

like personalized hotel rooms, fast check via a mobile device, etc., will become a real need in every hotel worldwide.

As a result, Costa Navarino saw this need, draw on, transforms every year and add to their capital resources to offer their assets, products and services (like IoT Technology) and achieves sustainable business growth and creating value for all their stakeholders. The IoT is an integral part of tourism sector and W Costa Navarino is using IoT to automate every possible service for improving guest experience.

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References

1. Aggarwal, R., & Lal Das, M. (August 2012). RFID security in the context of "Internet of Things." *First International Conference on Security of Internet of Things, Kerala, 17–19*, 51–56. https://doi.org/10.1145/2490428.2490435
2. Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer Networks, 54*(15), 2787–2805.
3. Car, T., Pilepić Stifanich , L. J., & Šimunić, M. (2019). Internet of Things (IoT) IN tourism and hospitality: Opportunities and challenges, ToSEE—Tourism in Southern and Eastern Europe, Vol. 5, pp. 163–175.
4. Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems, 29*(7), 1645–1660. https://doi.org/10.1016/j.future.2013.01.010
5. Hakan, Ö. (2023). Bibliometric analysis and scientific mapping of IoT. *Journal of Computer Information Systems*. https://doi.org/10.1080/08874417.2023.2167135
6. ITU. (2015). Internet of Things Global Standards Initiative. Retrieved 17 January, 2019, from https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx.
7. Kansakar, P., Munir, A. & Shabani, N. (2017). Technology in hospitality industry: Prospects and challenges. arXiv preprint arXiv:1709.00105
8. Kosmatos, E. A., Tselikas, N. D., & Boucouvalas, A. C. (2011). Integrating RFIDs and smart objects into a unified internet of things architecture. *Advances in Internet of Things: Scientific Research, 1*, 5–12. https://doi.org/10.4236/ait.2011.11002
9. Kranenburg, R. V. (2008). *The internet of things: A critique of ambient technology and the all-seeing network of RFID*. Insitute of Network Cultures.
10. Mingjun, W., Zhen, Y., Wei, Z., Xishang, D., Xiaofei, Y., Chenggang, S., & Jinghai, H. (2012, October). A research on experimental system for Internet of things major and application project. In 2012 3rd International Conference on System Science, Engineering Design and Manufacturing Informatization, IEEE, Vol. 1, pp. 261–263.
11. Nunberg, G. (2012). The Advent of the Internet: 12th April, Courses.
12. Sethi, P., & Sarangi, S. R. (2017). Internet of things: Architectures, protocols, and applications. *Journal of Electrical and Computer Engineering, 2017*, 1–25. https://doi.org/10.1155/2017/9324035
13. Verma, A., & Shukla, V. (2019). Analyzing the Influence of IoT in Tourism Industry," in International Conference on Sustainable Computing in Science, Technology & Management.
14. Ystgaard, K. F., Atzori, L., Palma, D., Heegaard, P. E., Bertheussen, L. E., Jensen, M. R., & De Moor, K. (2023). Review of the theory, principles, and design requirements of human-centric Internet of Things (IoT). *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-023-04539-3

Company's Sustainability Report

15. https://www.costanavarino.com/wp-content/uploads/2022/05/sustainability-2019_20.pdf

Destination Website

16. https://www.costanavarino.com/

Hotel Websites

17. The Westin Resort Costa Navarino → https://www.marriott.com/en-us/hotels/klxwi-the-westin-resort-costa-navarino/overview/
18. The Romanos, a Luxury Collection Resort → https://www.marriott.com/en-us/hotels/klxlc-the-romanos-a-luxury-collection-resort-costa-navarino/overview/
19. W Costa Navarino → https://www.marriott.com/en-us/hotels/klxwh-w-costa-navarino/overview/

Mobile Applications

20. Marriott Bonvoy Mobile Application → https://mobile-app.marriott.com/en-us
21. Costa Navarino Mobile Application → https://apps.apple.com/us/app/costa-navarino-greece/id1458397325?l=el&ls=1

TripAround Application

22. https://www.triparound.com/
23. https://www.fortunegreece.com/article/triparound-metaschimatizontas-psifiaka-ton-touristiko-klado/

KNX installation Application

24. https://www.knx-iotech.org/

LG application

25. https://www.lg.com/us

Chapter 2
Anomaly Detection in Enterprise Payment Systems: An Ensemble Machine Learning Approach

Basem Torky, Ioannis Karamitsos, and Tariq Najar

Abstract With the exponential growth of digital transactions, ensuring the integrity and authenticity of payment systems has become imperative. This paper investigates the effectiveness of machine-learning techniques in detecting anomalous patterns in large-scale payment datasets. Ensemble methods are widely used in the field of anomaly detection in enterprise systems to improve the accuracy and robustness of these systems. Anomaly detection aims to detect abnormal patterns that deviate from the rest of the data and are referred to as anomalies or outliers. With millions of services or sub-systems to monitor such as e-commerce platforms and governmental portals, our study focuses on using forecasting methods to develop a model that can be used in these enterprise systems to avoid huge financial impacts, bad reputation, and customer dissatisfaction. Our methodology combines multiple time series methods such as Seasonal Autoregressive integrated moving average (SARIMAX) and Facebook-Prophet and SVM to create a more robust and accurate ensemble model for anomaly detection. Anomaly detection can help highlight where exactly an incident is occurring. This proactive detection greatly improves the root cause analysis of the problem and has a positive impact on business continuity. The three different types of anomalies can occur in the datasets of pointers, conditional, and collective or accumulative anomalies. The main approaches to solve anomaly detection problems are either rule-based or machine learning approaches. In this paper, we focus on the machine learning approach as it is more reliable and effective as it complements the rule-based human capabilities with the machine learning and artificial intelligence capabilities. Three widely used forecast models SARIMAX, Facebook-Prophet and SVM are compared and analysed for the payment transactions. For the evaluated performance SVM model is best performed with R squared accuracy values of 80.7%. Overall, the results demonstrated that the SVM method can provide better performance than SARIMAX and Prophet methods for payment transactions data.

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Keywords Anomaly detection · ARIMA · Forecasting · Facebook-prophet · Proactive anomaly detection · SARIMA · SVM

Introduction

Anomaly detection can assist in pinpointing the exact spot of an incident amongst millions of services or sub-systems that need to be monitored. This proactive detection greatly improves the root cause investigation of the problem and has a beneficial impact on business continuity.

As we begin to solve the problem, it is critical that we identify the kind of anomaly that we are working with. The datasets may contain any one of the three different categories of anomalies listed below:

1. Pointer anomalies: these clearly visible dataset outliers require further investigation to determine whether they represent anomalies or false positives.
2. Conditional Anomalies: These are the data points that, only in a certain situation, deviate from the dataset's overall normal distribution. Seasonality in a time series data set is a common example.
3. Collective or Accumulative Anomalies: These are the data points that, when repeated consecutively, may raise an indication of an anomaly even though they appear normal on their own.

The problem of anomaly detection can be approached in a variety of ways. However, we will focus on two primary methods here:

- **Rule-based anomaly detection**: this technique requires a subject matter expert to develop the rules based on his experience and involves the programmer defining a set of rules for the anomaly detector to apply over a dataset.
- **Machine learning anomaly detection**, which defines and distributes the anomalies throughout the dataset primarily through machine learning techniques and algorithms. Due to the utilization of machine learning to enhance human capabilities, this technique is more dependable and efficient.

These days, managing and anticipating disruptions to any corporate system is extremely difficult. These disruptions, which various factors can bring on, can significantly negatively influence finances, reputation, and customer satisfaction. Determining the anomalous deviations in extensive runtime dataflow that includes useful system logs for a functional system is a complex procedure requiring profound technical and commercial knowledge. The impacted businesses are looking for irregularities such as equipment failure during operations, fraud in the finance sector, or cybersecurity.

This study aims to explore the effectiveness of machine learning-based anomaly detection in predicting anomalies and portal outages within an online services portal. In our research study is used a dataset of detailed financial transaction data

for an online services portal. Using machine learning techniques, we can forecast abnormalities and portal outages based on past data.

The main contribution of this paper is:

- Developing three time series models to predict the anomalies in order to identify the next service interruption or outage that should be avoided;
- Selecting the best model in terms of the performance.
- Creating real-time dashboards (BI) in order to address the anomalies and lessen their impact by creating an alerting mechanism in the event that a predetermined error threshold is exceeded.

This remainder of the paper has been organized in the following way. Section 2.2 begins by laying out the related work on anomaly detection. Section 2.3 is concerned with the time series modelling methodology used for this study. Section 2.4 presents the findings of the study, focusing on the comparison between different forecasting models for the anomaly detection of the payment transactions. In Sect. 2.5 analyses the results of selected time-series model with real dataset implementing forecasting models. Finally, in Sect. 2.6 the conclusion gives a brief summary of the findings and areas for further work are identified.

Related Work

The literature review delves into various approaches for anomaly detection through machine learning in diverse contexts. In their study, Wang et al. [1] specifically investigated the identification of abnormal accounts in online banking. They achieved this by analyzing the geonet features of each account and identifying distinctive patterns that set outliers apart.

Hisham et al. [2] highlighted the efficacy of ensemble approaches amalgamating weak models to create more robust ones, supported by earlier studies showcasing the accuracy gains from combining ensemble techniques.

In their study, Nkongolo et al. [3] presented a new dataset for anomaly detection, incorporating cyclostationary zero-day threat behaviors. The researchers deployed Random Forest and Decision Tree algorithms together with an Ensemble Learning strategy approach to analyze the data.

Petrariu et al. [4] explored unsupervised anomaly detection algorithms on an IT department's traceability dataset, achieving up to 91.73% accuracy in identifying abnormal transitions.

Hajialian and Toma [5] developed a model using the ML Pipeline, showcasing high precision and accuracy, especially with 32 trees in the Random Forest classifier.

Zhao and Keikhosrokiani [6] integrated RFM analysis and multiple analytics algorithms for sales prediction and product recommendation, achieving a 77.82% accuracy rate.

Abdelrahman and Keikhosrokiani [7] scrutinized assembly data, utilizing KNN and ABOD algorithms to identify aberrant data points and causes without over-rejection in assembly machines.

Pavlyshenko [8] favored regression over time series analysis for sales forecasting, employing stacking to enhance accuracy.

Kotios et al. [9] established the foundation for novel financial services by proposing a hybrid transaction categorization model and an accurate cash flow prediction model.

Ibrahim et al. [10] utilized Facebook-Prophet, AutoEncoder Long Short-Term Memory, and Isolation Forest algorithms to detect anomalies in photovoltaic components. Among these algorithms, AutoEncoder Long Short-Term Memory had the highest level of accuracy.

Soro et al. [11] conducted a study on detecting anomalies in banking transactions. They are utilizing adaptive threshold algorithms and unsupervised machine learning on a dataset of over two thousand customers to provide a reliable solution for real-time or semi-real-time anomaly detection.

Edholm [12] successfully obtained an accuracy rate of 87% in detecting anomalies by utilizing Artificial Neural Networks for invoice processing in a company experiencing unidentified revenue loss.

Knutsen [13] recognized the effectiveness of Bayesian networks in managing service and availability risks. The Nova system outperformed Sensex in terms of detection and scoping time, while still preserving accuracy. This was achieved by adding the causal structure of the service. Collectively, these research provide significant contributions to the understanding of various anomaly detection methods and their practical implementations in various fields.

Research Methodology

In this study, we applied the methodology includes multiple and various steps and activities. In Fig. 2.1 is depicted the overall time series process flow.

Data Collection and Preprocessing

The collected "Payment Transactions" dataset contains 10 attributes, the time range from 2014 to 2023 but for the study purpose and due to the memory limitation, we will take the year of 2022 as a base for all the modeling and visualization (Table 2.1).

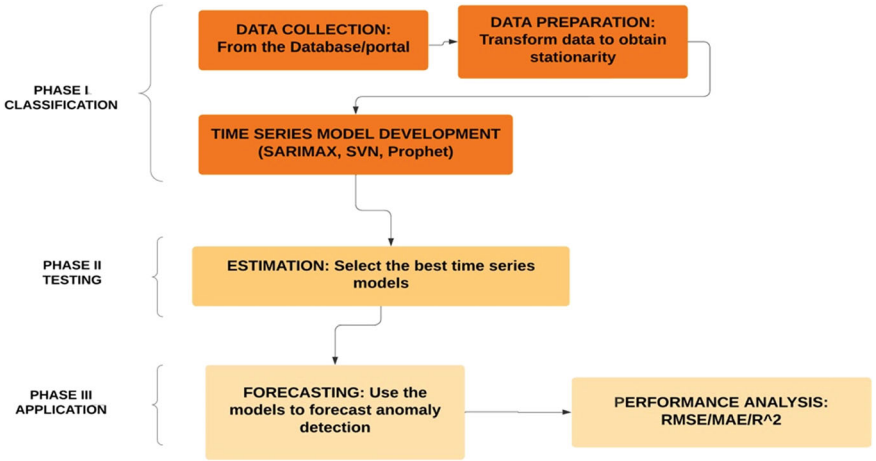

Fig. 2.1 Time series process flow

Table 2.1 Data dictionary

Variable name	Data type	Description
CREATED	Timestamp	The transaction created date
TXN_ID	String	It is the transaction unique number
ACTIVITY_TYPE	Categorical	It is the payment method type (GooglePay, ApplePay, etc.)
APP_NAME	Categorical	The application name used to complete the transaction
AMOUNT	Integer	The transaction paid amount
BENIFICIARY_TYPE	Categorical	The customer type (individual or corporate)
SERV_CODE	Categorical	The unique service code
SP_CODE	Categorical	The service provider unique code
STATUS	Categorical	The transaction status (success or failed)
SERVICENAME	String	The provided service name

Time Series Model Development

We employ a range of time series models to develop anomaly detections models. These models are trained on historical data to identify patterns indicative of anomalies.

Facebook-Prophet Model

The Facebook library called Facebook Prophet is used to forecast time series data with multiple or non-linear growth. The library fits a time series dataset to an additive

model using Bayesian inference, as stated in the following formula:

$$X(t) = T(t) + S(t) + H(t) + \varepsilon_t$$

where:

- T(t): is the dataset trend
- S(t): is the time series seasonality
- H(t): holidays values
- ε_t: unpredicted/error/bias effects

SARIMAX Model

The statistical model known as SARIMAX is commonly employed in the analysis and prediction of time series data. It is an altered variant of ARIMA designed to enable time series that exhibit seasonality over the course of the dataset. Its acronym, as shown below, is ARIMA (p, d, q) × $(P, D, Q)_s$:

- (p, d, q): indicating non-seasonal properties
- (P, D, Q): indicating seasonal timeseries part
- S: indicating seasonality periodicity

Support Vector Machines Model

The Support Vector Machines (SVMs) is a highly potent and versatile machine learning model capable of performing linear or nonlinear classification, regression, and more over can identify outlier identification. Support Vector Machines (SVMs) are particularly suitable for classifying datasets that are both complex and of small or medium size. To transform our transactions time series dataset into a supervised machine learning issue, we will employ the sliding window technique. The SVM results obtained from the dataset with engineered features could potentially serve as a performance benchmark for the given challenge.

Experimental Analysis

During this part of the time series process, which is essential as it entails collecting all the information and displaying it in a visually captivating chart or graph, we will focus on delivering intriguing descriptive analytics insights from our data collection. Additionally, it is vital for presenting the business stakeholders with a clear and comprehensible visual depiction of our discoveries. We graph the temporal distribution of payment transactions using a dataset of transactions. The timeseries graph presented below illustrates a rising trend in the year 2022, indicating a progressive increase in the utilization of this service over time. This input has the potential to

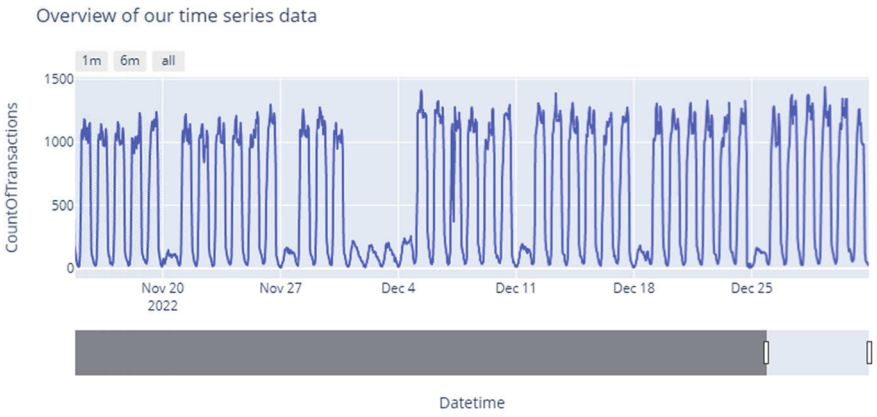

Fig. 2.2 A month timeseries overview

be valuable for capacity planning in the upcoming year. We saw a slight decline in the number of transactions throughout the months of May, July, and December. This decrease will be further analyzed when we develop our model (Fig. 2.2).

To determine the frequency of transaction count over time, it is beneficial to create a histogram graph. The histogram graph will provide valuable insights into the timeseries data. The histogram below illustrates that the values below 200 correspond to the most recent data point (Fig. 2.3).

SARIMAX Model

Our timeseries clearly exhibits seasonality, as we demonstrated throughout the data discovery process. For this reason, ARIMA is not the best model choice to reflect a fitted model; nevertheless, SARIMAX can be useful in these situations.

With our dataset, p, d, and q values of 1, 1 and 1, respectively, we will apply SARIMAX (p, d, q) × (P, D, Q). The values of P, D, and Q are 1, 1, and 0, correspondingly. Since our timeseries has a weekly seasonality, the final value is the s, or the seasonality value, which in our case is 7 (days).

The train dataset, which spans the years 2020–01–01 to 2022–10–01, and the test dataset, which spans the years 2022–10–01 to 2023–01–01, are the two subsets of our cleaned dataset.

The numerical results of our model are displayed in Fig. 2.4.

Additionally, Fig. 2.5 illustrates the contrast between the predicted vs observed sample.

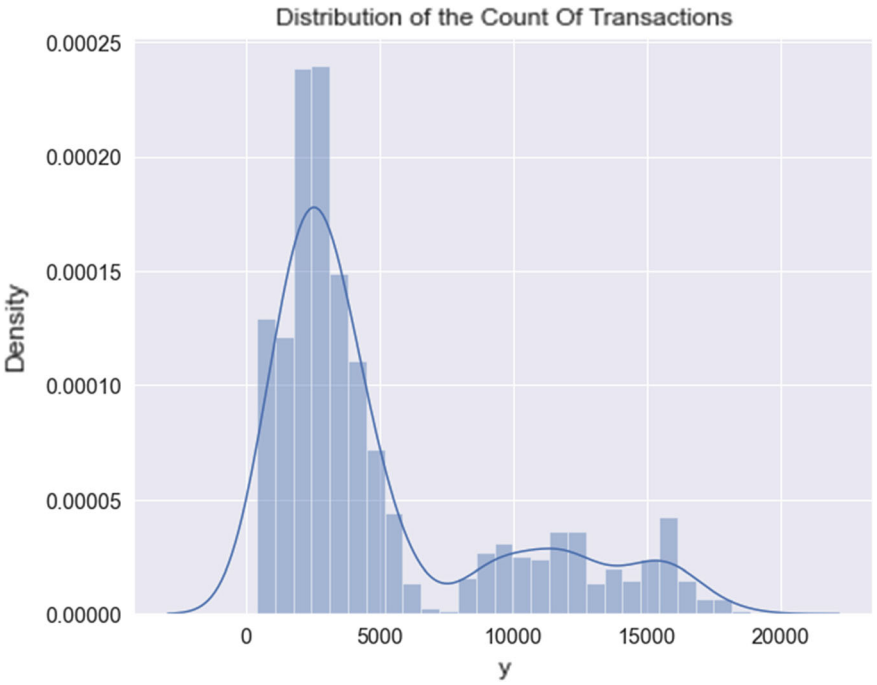

Fig. 2.3 Distribution of the count of transactions

SARIMAX Results

Dep. Variable:	value	No. Observations:	1004
Model:	SARIMAX(1, 1, 1)x(1, 1, [], 7)	Log Likelihood	-241.807
Date:	Sun, 16 Apr 2023	AIC	491.614
Time:	06:22:25	BIC	511.229
Sample:	01-01-2020	HQIC	499.071
	- 09-30-2022		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.6291	0.015	42.545	0.000	0.600	0.658
ma.L1	-1.0000	0.836	-1.196	0.232	-2.639	0.639
ar.S.L7	-0.5160	0.012	-43.741	0.000	-0.539	-0.493
sigma2	0.0943	0.079	1.192	0.233	-0.061	0.249

Ljung-Box (L1) (Q):	3.00	Jarque-Bera (JB):	4514.88
Prob(Q):	0.08	Prob(JB):	0.00
Heteroskedasticity (H):	2.37	Skew:	-0.78
Prob(H) (two-sided):	0.00	Kurtosis:	13.31

Fig. 2.4 SARIMAX model results

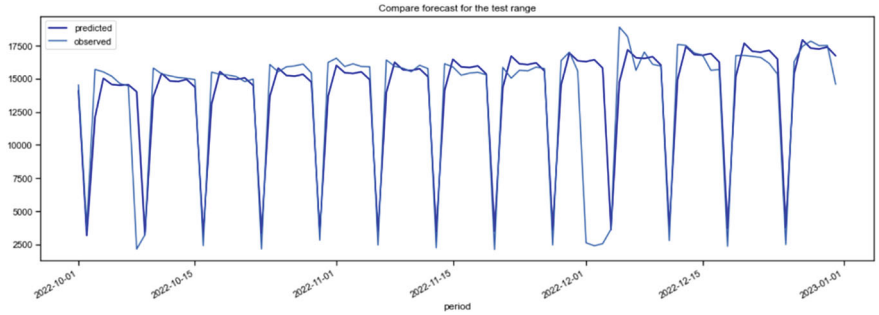

Fig. 2.5 Predicted versus observed sample

Facebook-Prophet Model

We began by configuring our model values as shown below Fitting the model is the next step (Fig. 2.6).

The model will be utilized to identify any anomalies, as shown below, where the anomalies are shown by red dots (Fig. 2.7).

	MAE_val	RMSE_val	Loss_val	RegLoss_val	epoch	MAE	RMSE	Loss	RegLoss
0	31611.388672	34557.273438	1.595960	0.0	0	23681.312500	28197.478516	0.944851	0.0
1	6726.849609	8573.799805	0.155113	0.0	1	12625.720703	15345.387695	0.376549	0.0
2	2766.475830	3667.225342	0.029396	0.0	2	4425.110352	5401.743164	0.051740	0.0
3	2250.795898	3781.328125	0.031270	0.0	3	2229.144531	2857.795898	0.014016	0.0
4	2225.123047	3696.863770	0.029881	0.0	4	1934.563354	2605.147217	0.012449	0.0
5	2324.956299	3779.929932	0.031238	0.0	5	1880.579712	2554.881592	0.012038	0.0
6	2209.526611	3736.277832	0.030520	0.0	6	1868.767944	2537.136963	0.011944	0.0
7	2507.412109	3785.434570	0.031321	0.0	7	1759.342529	2480.170654	0.011751	0.0
8	2437.001709	3717.328369	0.030205	0.0	8	1786.683594	2415.203857	0.011285	0.0
9	2415.369141	3719.059570	0.030233	0.0	9	1791.072266	2439.281494	0.011197	0.0

Fig. 2.6 Model fitting results

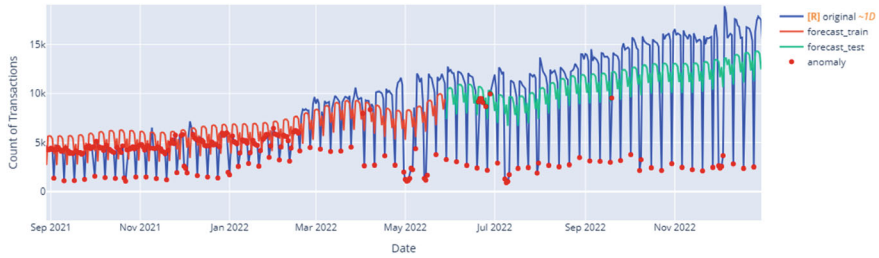

Fig. 2.7 Anomalies points representation

Support Vector Machines Model

We choose GridSearch CV with 5 k-folds since it is essential to determine the prober parameters for any machine learning model to maximize the accuracy of the anomaly detection capabilities. Conversely, the SVM general algorithm was utilized to adjust its parameters, such as the cost parameter and the decision border gamma curviness rate, gamma.

The GridSearchCV cross validation results are displayed in Fig. 2.8. With a score of 0.826, the best adjusted parameters were C at 15.85 and gamma at 0.032.

Afterwards, we plotted the observations from training, validation, and testing against the actual observed values. This shows that the testing and validation datasets have strong prediction, which will result in high performance accuracy (Fig. 2.9).

Providing insight into the validation set and the prediction outcomes in relation to the actual observed values, which show a strong degree of similarity (Fig. 2.10).

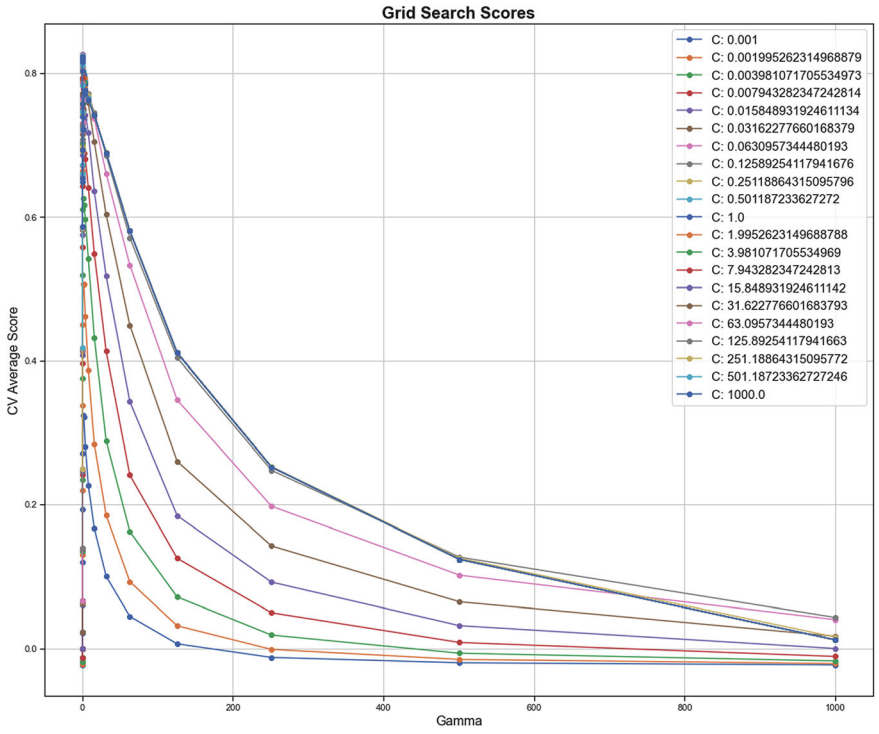

Fig. 2.8 GridSearchCV scores