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PRIMARY RESEARCH

Enhanced airport operations: Automated baggage drop-off and boarding pass generation for travelers

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Abstract

This report investigates the design and implementation of a more advanced automated system aimed at transforming airport operations through advanced baggage drop-off and boarding pass generation for passengers. Especially on public holidays or any festival, it will be helpful in removing the queues in airports for check-in and boarding-pass generation, which will save much time and make it faster; due to a straightforward interface, there will be less interaction with airport staff and the luggage mishandling will be less. The fundamental objectives of the project include creating a user-friendly and responsive self-check-in kiosk that integrates Internet of Things (IoT) technology for a seamless baggage handling experience. An innovative function of the device is the inclusion of a camera that captures pics of the luggage and saves it with the passenger's data and prints a QR code on the passenger's boarding pass; by scanning the QR code, passengers can see the pictures of their baggage. The QR code improves safety and guarantees the green tracking of baggage. Furthermore, this system is for general purposes, which allows all the travelers of different airlines to use a single system for check-in and generating their boarding passes. This method will optimize space utilization at airports and cut down operational fees. The reason for the report is to feature the development of a flexible, scalable, and steady kiosk machine appropriate for both vast and small airports, accepting weighty luggage and catering to the desires of diverse airlines. Implementing an IoT system ensures a streamlined check-in method, significantly improving the tour experience for passengers. The record concludes that the generalized luggage drop-off system not only offers operational performance but also sets a brand-new trend for automated airport offerings.

I. INTRODUCTION

In this era of technology, airport self-check-in and luggage drop-off systems are the primary choices for the different airlines at the airports. With the combination of software and the Internet of Things (IoT), this system is effective for all big and small airports. The purpose of this generalized system is to save time and ensure efficient travel experience for passengers through all the airlines with a single machine [1, 2]. The well-organized design of the modern kiosks can be impactful for travelers to avoid the lines during check-in and dropping their luggage. This system allows passengers to self-check in, weigh their luggage, print luggage tags, drop their luggage at conveyor belts and print their boarding passes [3, 4]. Travelers can weigh multiple bags under certain conditions and print their luggage tags many times [5, 6]. Passengers can also pay for the extra weight if they are willing to pay; otherwise, they are allowed to reduce the weight of their luggage to meet the minimum allowed weight capacity. Multi-ticket holders can weigh their luggage at all, and the net weight will be calcu-

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lated [7]. To increase security and reduce the damage and mismanagement of the luggage, this system takes a picture of the luggage, prints it on the boarding pass, and saves it in the database with the passenger's details [8, 9]. The main advantage of the system is that it makes airports humanless, saves the time of travelers, and provides them with an efficient and effortless way with the help of a user-friendly and responsive design of the system, which caused its success [10].

A. Problem Statement

The current system (kiosks) is designed for a specific airline [11]. If every airline contains a separate machine at the airport, it will be expensive. The individual machine for each airline not only holds too much space in the airport, but passengers also face many difficulties, such as finding the airline's drop-off system [12]. The main problem of saving time has not been solved for those airports that have only one drop-off system for each airline. Passengers must wait in line to check in and drop off their luggage, just like the manual system [13]. Many passengers complained about the mismanagement of their luggage. Most passengers are right, but sometimes they try to damage the image of the airline and claim that the airline staff damaged their luggage, which was already damaged [14]

RELATED WORK

B. Usability Evaluation of Airport Self-Service Kiosks

This paper values the serviceability of self-carrier kiosks (SSKs) at airports, focusing on their device and purchaser interface. Using a case has a test method; the authors conducted surveys and observational studies at a number one airport to recognize passenger evaluations with SSKs. The study determined numerous usability issues, together with the complicated interface, dubious commands, and insufficient remarks mechanisms. The authors cautioned layout enhancements to decorate the patron revel, which embodies a much less complex interface, the use of excellent intuitive icons, and real-time assistance through interactive help capabilities [15].

C. Universal Check-In Systems in Airports

These studies explore the idea and implementation of complete check-in systems at airports, which allow passengers to check in with any airline in a single, standardized manner. The researcher analyses the central blessings of such structures, consisting of reduced equipped times, progressed performance, and more passenger pleasure [16]. They additionally communicate the technical and logistical challenges involved in integrating various airline systems right into a widespread platform. The paper concludes that, at the same time, common test-in systems provide big blessings, and an achievement implementation calls for careful planning, collaboration among stakeholders, and robust technology infrastructure.

D. Enhancing Baggage Security with Image Recognition Systems

This journal explores using photo recognition structures to beautify luggage protection. The authors explain the equipment inside the lower back of photo recognition, concerning machines getting to know algorithms and immoderateresolution cameras, and the way it could apply to find banned devices in bags [17]. The paper gives a case study of an airport that achieved a picture recognition tool, highlighting the enhancements in detecting accuracy and processing pace. The authors also bear in mind the annoying situations of making use of such systems, together with privacy concerns and the need for nonstop updates to the recognition algorithms [18]. The study concludes that while photograph recognition systems substantially beautify safety, their achievement depends on cautious implementation and ongoing protection.

E. QR Code-Based Information Systems In Airports: An Implementation Perspective

This paper investigates the implementation of QR codeprimarily based records structures in airports. The authors explain how QR codes can be used to provide passengers with real-time records, which include flight status, gate adjustments, and luggage claim info [19, 20]. The analysis consists of an in-depth evaluation of the technical necessities for enforcing such structures, such as QR code technology, scanning infrastructure, and records management. The authors present case research from airports which have successfully deployed QR code systems, demonstrating improvements in passenger statistics dissemination and delight [21]. It additionally discusses demanding situations, ensuring the tremendous availability of QR code readers, and maintaining up-to-date statistics.

F. Reducing Baggage Mishandling With Automated Systems

This paper specializes in the role of automatic structures in reducing bag mishandling at airports. The authors examine the motives of baggage mishandling and the way automation can deal with one's problems [22]. They assess various computerized structures, which include RFID mon-

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itoring, automatic sorting systems, and actual time monitoring equipment. Case studies at airports have accomplished those technologies presented, showing good-sized discounts on mishandling fees and associated expenses. The paper also reviews the annoying situations of enforcing computerized structures, such as excessive initial investment and the need for employee training. The authors end by saying that while automation gives widespread blessings, it calls for cautious planning and ongoing help [23] .

G. Research Gap

There is a need to develop a universal system that seamlessly integrates with all airlines and airport functionalities, and the implementation of the camera on a system decreases luggage mishandling. This system would address the current limitations of divided technologies by providing a single system for passengers, regardless of their chosen airline:

- There is a need to develop a general-purpose system that can be accessible by passengers of any airline.
- The system is required to enhance the reliability and accuracy of the self-check-in system.
- Implement a camera on the system that captures the images of luggage and addresses associated privacy concerns.
- A user-friendly design is missing from the traditional methods; hence, a responsive interface for the system is required to improve user acceptance.

II. METHODOLOGY

This section covers all the techniques, methods, and tools for creating this project. Firstly, we will discuss the needs of this project. It is an automatic baggage drop-off and boarding pass generator for travelers. It helps the passengers to save their time and money and provides an intuitive and universal experience. It also allows airports and airlines to manage passenger traffic at peak times. Our project objective is to create a system that provides a user-friendly interface for passengers to check in and print their passes, like bag tags and boarding. We also integrate a camera that captures the baggage image and combines it with passenger details. A general-purpose system is introduced that can access any passenger of any airline without any problem. To design and develop this system, we need a scanner, a weigh conveyor, a camera, a thermal printer, a display panel, and an application that operates. The scenario of operation is that a passenger comes to the airport and finds the machine. After coming to the machine, it scans the documents the scanner; if the data is valid, the system processes and shows the passenger de, it After the check-in, the system asks for baggage; if passengers have bags, the system processes the weight measurement and measure the weight if condition is meet to passenger detail, system generate the bag tags and move for boarding pass generation. If conditions do not meet with passengers allow weight system display for overcharges. A person pays the charges, and then the system generates the bag tags and moves on; otherwise, it shows an alert for matching conditions. This entire system is based on hardware and software, so we are using this tool and method for design and development. We are using the ESP32 Microcontroller to connect hardware components to software applications. A Low-device driver is installed in the microcontroller using Python libraries that help integrate system components. This microcontroller has a built-in Wi-Fi and Bluetooth module and is used to transfer the data from input devices to the display panel and database. A weigh conveyor load cells connected to HX711 amplify that convert the measured load into binary form and further connected to ESP32, while an ESP32 Cam is also connected to this controller. All the actions are triggered by the application that sends the signal to the controller that helps to perform the task of different components. A system application base on HTML, CSS, and Python language, and it is a library with a small database. We also consider the non-functional requirements like system scalability, accessibility, reliability, security, and maintenance and updating.

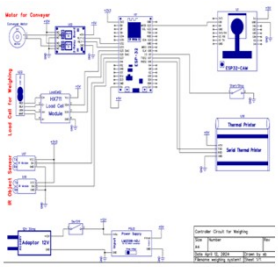

Fig. 1. Circuit diagram

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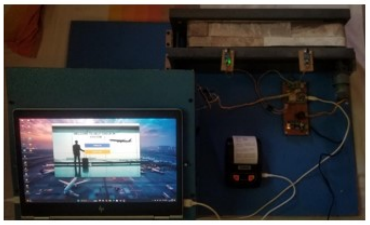

Fig. 2. System Design

The implementation of the Enhanced Airport Operations system has revealed significant advantages and implications for airport management. This innovative solution has the potential to transform how airports manage check-in, baggage drop-off, and passenger flow. Here is a comprehensive look at the key findings:

A. Operational Efficiency

The main objective of this system was to boost operational efficiency, particularly during peak travel periods. By automating the baggage drop-off and boarding pass generation, the system dramatically shortened the time passengers spend waiting in line. In tests, passengers completed their processes in an average of 3-5 minutes, compared to the usual 15-20 minutes with manual systems. This time savings is especially crucial during busy travel seasons, such as holidays, where it can significantly alleviate congestion and improve the passenger experience. Given the increasing number of travellers, this scalable solution equips airports to manage more traffic effectively while reducing delays.

B. User Experience

Participants in the tests were impressed by the system's user-friendly design. The interface effectively guides passengers through the check-in and baggage drop-off steps, allowing 95% of users to complete the process independently. This represents a major improvement over existing systems, which often require staff assistance. A smoother, easy-to-navigate experience is vital for improving customer satisfaction in the aviation sector. With less need for passenger interaction with staff, airport personnel can concentrate on more complex tasks like security and customer service, thus enhancing the overall service quality.

C. Security and Luggage Tracking

A standout feature of the system is its use of image capture technology that connects luggage images to passenger data. This not only enhances baggage tracking but also reduces the likelihood of lost or mishandled luggage. Passengers can view images of their bags via a QR code on their boarding pass, adding an extra layer of security. This innovative method is particularly beneficial for addressing the ongoing challenges of baggage mishandling, a common issue in almost every airport around the globe. The combination of image-based tracking and QR codes fosters a more secure and transparent process for both travellers and airlines, boosting passengers' confidence in the handling of their belongings.

RESULTS

The analysis of the results from the developed system indicates that the system successfully addresses several challenges in airport operations which will increase the productivity of airports across the globe. The following shows the key findings of our developed system. The automated system significantly reduced the time passengers spent on check-in and baggage drop-off processes. On average, each passenger saved 3-5 minutes compared to traditional check-in methods, particularly during peak travel periods. This was achieved through seamless integration of the luggage weighing, image capture, and boarding pass generation processes. By replacing multiple airline-specific machines with a single generalized system, the space utilization at the airport was optimized. This not only saved valuable space but also reduced infrastructure costs for airports. The inclusion of the camera and QR code feature improved baggage security. By associating luggage images with passenger details and making them accessible via QR code, the risk of baggage mishandling and theft was minimized. This system provides real-time tracking and increased transparency, reassuring passengers of the security of their belongings. The automated nature of the system significantly reduced human errors. For example, the weight measurements were consistent, and no instances of luggage being misdirected due to incorrect tagging were reported.

III. CONCLUSION

In conclusion, this research underscores the transformative ability of automation in airport operations. The findings discover that deploying automated systems can extensively enhance performance, lessen ready times, improve passenger pleasure, and lower operational fees. Significant to

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those outcomes is a person-targeted design that prioritizes patron pleasure and the integration of common test-in systems, which enable the use of the identical system through passengers of any airline. Additionally, using picture seize technology offers superior security measures. However, demanding circumstances together with technical reliability, system integration, and passenger reputation maintain to be vital areas that need centered thought to make sure a hit implementation of upgraded computerized structures in airports.

Contributions to the Field

This research provides several significant contributions to the field of automated airport systems:

User-Friendly System: We have designed a user-friendly interface in our system which will help the passengers to navigate with the system without any guidance.

IoT Integration: we are integrating Internet of Things (IoT) technology into our system to enhance the functionalities of luggage weighing and capturing the pictures, luggage tag printing, payments for extra weight, and generation of boarding-pass. This IoT-based approach ensures a streamlined and efficient process in an airport.

Secure Luggage Handling: Our modern approach includes installing cameras in the kiosks to take images of luggage, which are uploaded with the passenger data and can be accessible through QR code which will be printed on the passenger boarding-pass. This technique addresses security concerns and adds an extra layer of authentication.

Enhanced Flexibility: The system allows travelers to print luggage tags multiple times for multiple bags within the allowed weight limits or for overweight bags after paying the extra charges, adding flexibility for passengers, and removing any external guidance of airport staff.

Generalized System for All Airlines: A major involvement in the development of a generalized system that can be used by passengers of all airlines through one system, including multi-ticket holders on a single booking number. This feature ensures broader applicability and convenience for travelers and makes it easier for travelers to check-in and generate their boarding-passes by themselves.

IV. FUTURE RECOMMENDATIONS

We have proposed several suggestions for future studies and development of automated airport systems:

A. Accuracy and Reliability

Enhancing the accuracy and reliability of self-check-in systems is crucial. Because frequently using the system may require maintenance of the system automatically when needed. Future studies should explore advanced technologies and algorithms that can make alerts of system maintenance required and overall improve system performance.

B. Privacy and Usability

Focusing on privacy and usability remain vital concerns in specially languages. Applying machine learning to identify the shape of baggage and print tags accordingly, and using IoT for automated tagging of luggage and double-check and requires confirmation from passenger which will ensures the data security.

C. Security of Health

Integrating health security measurements of a passenger, such as fever check thermometers, integrated into automated systems can provide considerable assistance, especially in addressing global health issues like pandemics.

D. Implementation of AI

Nowadays passengers want more interactive kinds of things, mostly cross communication channels like AI voice agent. By implementing artificial intelligence like chatbot or voice assistant, it will make the system more interactive and flexible for the users. Furthermore, voice assistants can work as a queries solver and by using it as multilingual, it will be easy to use by every language speaker.

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