IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

HOSPITAL QUEUE WAIT TIME PREDICTION

Ajinkya Mishra, Aryan Kapse, Kunal Nikam, Rajat Ingale, Prof. Suresh Jajoo

Department of Electronics Engineering,
Datta Meghe College of Engineering, Airoli, India

Abstract: This paper addresses the pervasive issue of prolonged wait times in hospital queues, leveraging machine learning, data science, and IoT technologies to develop an automated queue management and prediction system. The problem, rooted in real-life hospital experiences, is characterized by patient distress due to unpredictable wait times and the strain placed on hospital staff. To mitigate this, we propose a system that utilizes RFID tag-sensors to capture precise patient service process data, enabling real-time monitoring and data collection. We will employ and compare various simulation and prediction techniques, including Random Forest, Monte Carlo simulation, Queue Theory, and mean/standard deviation calculations, to determine the most accurate method for predicting queue wait times. The system integrates a Raspberry Pi for data processing and wireless transmission via NodeMCU, a MySQL database for data storage, and a Java Swing GUI for real-time monitoring and management. Real-time queue size, wait time, and next patient information will be displayed to enhance patient experience. By automating data collection and providing accurate wait time predictions, this paper aims to reduce patient anxiety, improve hospital efficiency, and optimize resource allocation.

Keywords: RFID, Queue Theory, Raspberry Pi, NodeMCU, MySQL, IoT

I. INTRODUCTION

Long wait times in hospital settings are a significant source of stress and frustration for patients and a challenge for healthcare providers. The unpredictable nature of these waits, particularly during emergencies or peak hours, can lead to patient anxiety, dissatisfaction, and even exacerbate existing health conditions. Furthermore, hospital staff, already burdened with clinical responsibilities, are often tasked with addressing patient inquiries about wait times, diverting their attention from critical tasks. This problem is further compounded by the lack of real-time information sharing and automated systems for queue management.

This paper aims to address this critical issue by developing an intelligent, automated queue management and prediction system. By leveraging the power of machine learning, data science, and Internet of Things (IoT) technologies, we seek to provide accurate wait time predictions, enhance patient experience, and optimize hospital resource allocation. We recognize the need for a system that not only monitors and manages patient flow but also provides patients with a clear understanding of their expected wait times, thereby reducing anxiety and improving overall satisfaction.

Our approach involves the implementation of a multi-stage queue system, utilizing RFID tag-sensors to capture precise patient service process data. This data will be analyzed using various simulation and prediction techniques, including Random Forest, Monte Carlo simulation, Queue Theory, and statistical methods, to determine the most effective approach for predicting queue wait times. The system will be designed to provide real-time updates on queue size, wait times, and patient progress through a user-friendly interface. By automating data collection, processing, and dissemination, this paper aims to create a more efficient, transparent, and patient-centric hospital environment.

II. LITERATURE REVIEW

the application of ML models to predict wait times in outpatient clinics. Their study, published in Procedia Computer Science, explored different ML algorithms to enhance patient flow and optimize scheduling in healthcare facilities. The research demonstrated that ML-based predictive models could significantly improve patient experience by reducing uncertainty in wait times. **[1]**

introduced a machine learning-based approach for estimating wait times in healthcare settings with multi-stage queues. Their study emphasized the importance of data-driven strategies in optimizing resource allocation and patient management in hospitals. By using multi-stage queuing models, their approach aimed to provide more accurate wait time predictions compared to traditional queuing theories **[2]**

extended the application of ML to predict waiting times across multiple domains beyond healthcare. Their study highlighted the adaptability of ML algorithms in modeling queuing systems, making a case for their effectiveness in various industries. **[3]**

present a comprehensive discussion on the Random Forest (RF) algorithm, explaining its underlying principles and its effectiveness in handling large datasets. The RF algorithm is an ensemble learning technique that builds multiple decision trees and aggregates their results to improve prediction accuracy. By combining multiple weak learners, RF reduces overfitting and enhances generalization in ML models. **[4]**

proposed an improved version of the Random Forest algorithm that enhances classification accuracy by measuring decision tree correlation. Their research suggested that traditional ML models could be further optimized by refining feature selection and decision tree structures, improving their accuracy in wait time prediction. **[5]**

analyzed the impact of hospital queue management systems in Nigeria. Their study assessed how technology-driven queue management systems improve efficiency and reduce patient wait times. Their findings underscored the necessity of digital transformation in healthcare services to enhance patient satisfaction. **[6]**

examined the role of queuing theory in optimizing patient registration processes in hospitals. While their work focused on mathematical modeling rather than ML, it provided foundational insights into queue dynamics, which could be integrated into ML-based predictive models. **[7]**

explored the effects of hospital queue management systems at AIIMS, New Delhi. Their research highlighted how integrating automated queue management with ML techniques could streamline hospital workflows and minimize patient waiting periods. **[8]**

III. PROBLEM DEFINITION

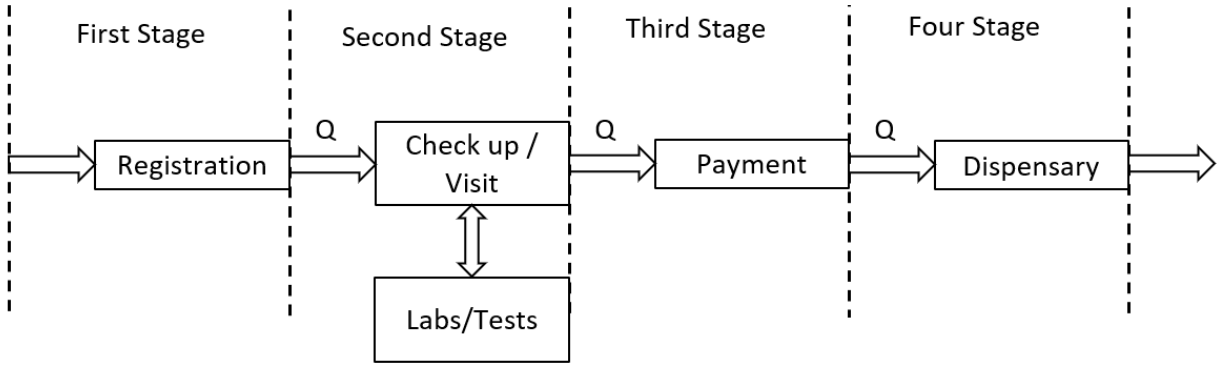
To predict the queue wait time more accurately by testing all the possible methods present for simulation and prediction using Machine learning and data science.

IV. MODEL DEVELOPMENT

We can relate this problem statement with our own real-life hospital experience. Even ignoring the overall stress associated with health risks, we have to spend a lot of time in infamously long hospital queues. In emergency cases, with limited resources, doctors may find their attention diverted to emergencies. Without an automated system to share real time information, this adds to the chaos of a hospital wait room. Hospital staff, already under pressure, is now burdened with the additional task of answering disgruntled patient's questions. Sometimes during the weekends, night times, hospitals get higher average wait time and inability to find the appropriate physician. Such higher waiting time in queues can be distressing and can raise tempers. However, this relationship is moderated when people perceive the future wait to be short or having an approximate idea of journey time before gets serviced and the consumer unhappiness is minimized.

V. APPROACH

Multi Stage Queue System:



Multi Stage Queue System

VI. CALCULATION

Available techniques for simulation and prediction are:

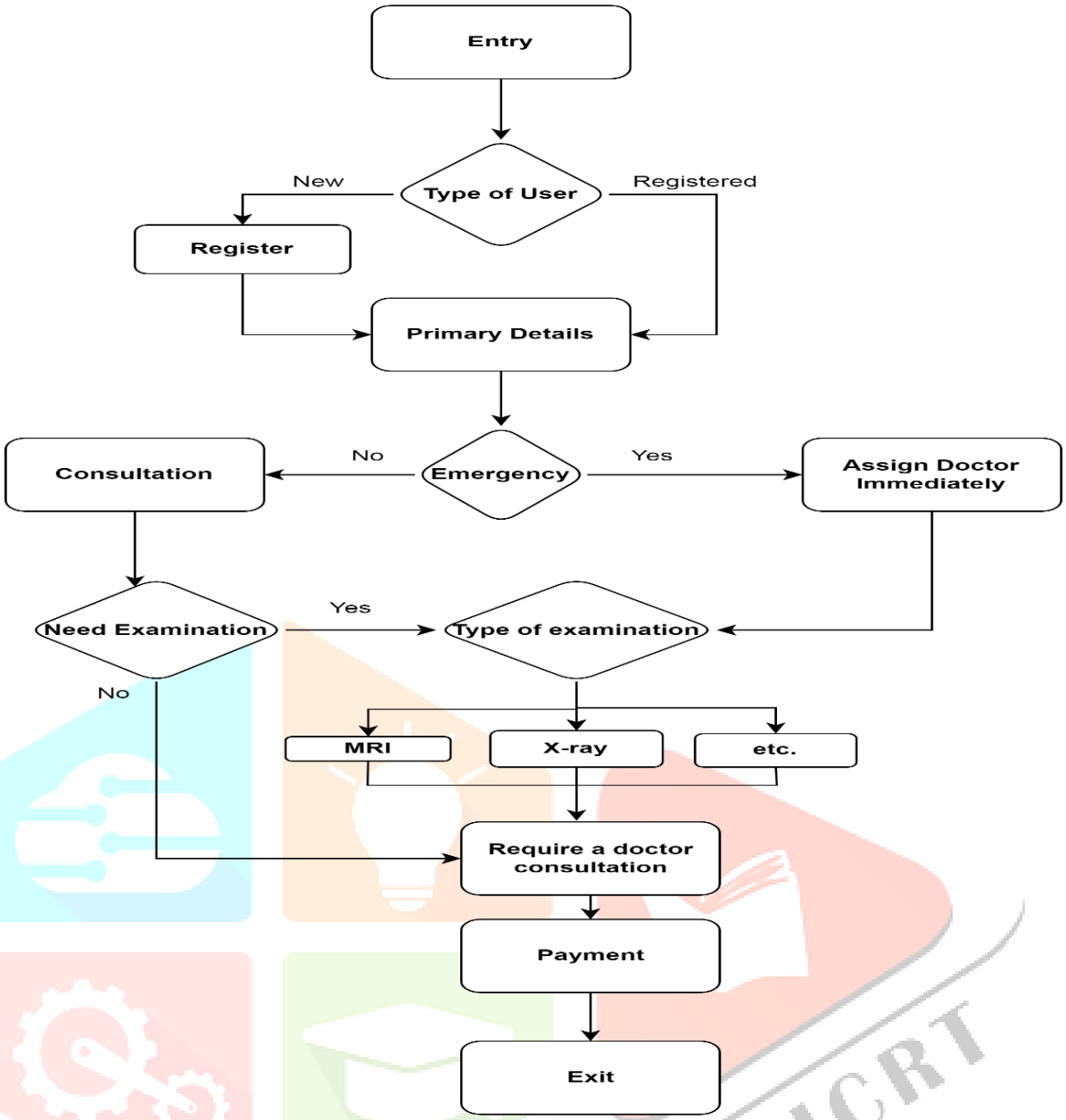
1) Random Forest
2) Monte Carlo
3) Queue Theory
4) Average mean with standard deviation

Our goal is to test the dataset with all the above possible methods and find the method to predict the Queue Wait Time more accurately.

VII. METHODOLOGY

Using RFID tag-sensor, we can get the highly accurate timing of patient's service process. Also, it will help monitoring and collecting data without any extra manual and paper work.

1) Registration: Registration process will save patients primary details into the database and will assign a RFID tag after successful registration.
2) Multiple Stages: Patient have to scan RFID tag at the entrance and exit of each stage with RFID reader module. This will help to automatically monitor patients' entrance and exit time without extra manual work and improve the accuracy with respect to time.
3) RaspberryPi: To get the RFID scanned data wirelessly using NodeMCU wifi module over LAN network. Also, to perform calculations for wait time prediction and store the collected and processed data on the database using remote access.
4) Counter and Timing Display:
   To display real time queue size and queue wait time. Also, to display the name of next patient in queue to get service.
5) GUI application using Java Swing: For registration, Reception Counter and other Executives' PC will have an access to monitor the real time data using GUI application created by using Java Swing with remote access to the database server.



a. Platform/Coding Language/Framework
   1) Platform: Windows, RaspbianOS (Linux)
   2) Programming Language: Python, Java, C, SQL
   3) Framework:
      - Python: Sklearn, Pandas, Matplotlib, Time, Math, MySQL connector, MQTT Server
      - Java: Java-Swing, MySQL connector
   4) Technologies Used: Machine Learning, Data Science, IoT

b. Database:
   - MySQL Server 8.0
   - Tables:
     - RealTime: to update and manipulate real time data
     - SingleDay: to store and keep daily record of the data
     - HospitalManagement: primary database with regular daily updates

c. External Tools
   1) RaspberryPi
   2) NodeMCU
   3) RFID Module

VIII. CONCLUSION

The Hospital Queue Wait Time Prediction system proposed in this study effectively addresses the challenge of prolonged and uncertain wait times in healthcare facilities. By integrating Machine Learning, Data Science, and IoT, the system automates queue management, enhances patient experience, and optimizes hospital resource allocation.

The implementation of RFID tag-sensors, Raspberry Pi, and NodeMCU ensures real-time patient tracking and data collection, eliminating the need for manual intervention. Various prediction models, including Random Forest, Monte Carlo simulations, Queue Theory, and statistical methods, were evaluated to determine the most accurate technique for queue wait time prediction. This comparative analysis allows hospitals to adopt the most efficient approach based on their specific operational requirements.

Through real-time queue monitoring via Java Swing GUI, patients gain better visibility into their wait times, reducing anxiety and improving overall satisfaction. Moreover, hospital staff benefit from automated tracking and prediction, enabling streamlined workflow management and enhanced service efficiency.

In conclusion, this paper demonstrates how technology-driven solutions can revolutionize hospital queue management, ultimately leading to reduced patient distress, improved hospital efficiency, and optimized resource utilization. Future enhancements can include deep learning models, cloud-based deployment, and scalability for large healthcare networks, ensuring a more sophisticated and robust system for queue management in hospitals.

References

References

[1] Jeffin Joseph*, S.Senith, A.Alfred Kirubaraj, Jino S.R Ramson(2022) **"Machine learning for Prediction of Wait Times in Outpatient Clinic"** Karunya Institute of Technology and science, Coimbatore, India

[2] Amjed Almousa, Hamza AL-Zubaidi, Mohammad Al-Dweik (2024) **"A machine learning based approach for wait time estimation in healthcare facilities with multi-stage queues"**

[3] Carolina Loureiro, Pedro jose pereira, Andre Pinho (2023) **"Predicting Multiple Domain Queue Waiting Time via Machine Learning"**

[4] Hasan Ahmed Salman, Ali kalakech, Amani Steiti (2024) **"Random Forest Algorithm Overview"**

[5] Zhigang Sun, Guotao Wang, Pengfei Li, Hui Wang, Min Zhang, Xiaowen Liang (2023) **"An improved random forest based on the classification accuracy and correlation measurement of decision trees"**

[6] Muhammad Ahmad Bablle, Aminu Ibrahim Idris, Usman Sani Farouk, Ahmad Usman (2022) **"Hospital Queue Management System Effects", Kano State Polytechnic, Nigeria**

[7] Meeta Tyagi, P.K Tyagi, Sanjeet Singh, Sunil Kant (2023), **"Impact of Application of Queuing theory on Operational Efficiency of Patient Registration", Department Mathematics and statistics university of Saudi Arabia**

[8] Abubakar Sani Muhammad, Jamilu Abdullhani, Zainab Abdulkardir (2022) **"The impact of Hospital Queue Management Systems",AIIMS New Delhi**