

Technique Bidirectional Visitor Counter

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Abstract

Bidirectional counters, electronic devices, or systems that track and count people or objects entering and exiting a specific space offer valuable insights into various applications. In marketing and sales, bidirectional counters are crucial in understanding customer behaviour, optimizing strategies, and enhancing overall performance. This paper investigates the design of a simple bidirectional counter application and evaluates its impact on marketing and sales. By tracking visitors, conversion rates, and visitor patterns, bidirectional counters enable data-driven decision-making and improved customer experiences. The paper highlights the potential of bidirectional counters as powerful tools for marketers and sales professionals, maximizing sales opportunities and driving effective marketing strategies to satisfy customers and increase profits.

Introduction:

The bidirectional visitor counter is pivotal in delivering a dependable and precise count of mall visitors. Its primary objective is to enhance sales and elevate the overall customer experience by effectively managing crowd control, encouraging social distancing, and maintaining a balanced flow of visitors throughout the day. The circuit consists of essential components, with the microcontroller serving as the central hub, overseeing all operations.

Incorporating sensors into the design enables the capture of signals, which are then processed by the microcontroller's software. Specifically, infrared receivers are employed and continuously monitored by the microcontroller. When an individual passes in front of an infrared receiver, the infrared rays are obstructed, indicating their presence. By carefully monitoring these signals, the microcontroller accurately tallies the number of customers in real-time. Fig. 1 depicts an example of a Bidirectional Visitor Counter (BVC).

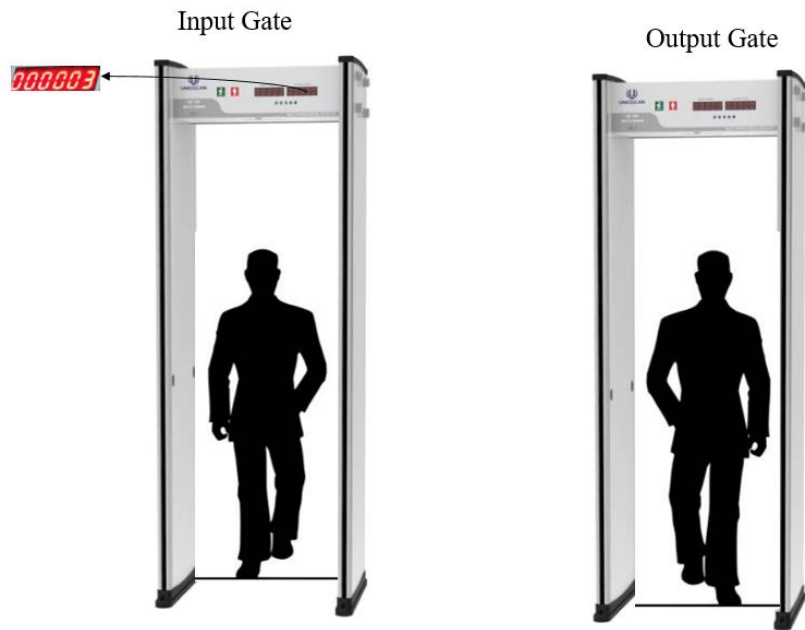


Fig. 1 *Bidirectional Visitor Counter*

The main advantage of this bidirectional visitor counter lies in its contribution to informed decision-making processes. The real-time visitor count data obtained can be used in the results section to make well-founded choices aimed at boosting sales and enhancing customer experience. By comprehending the visitor flow, identifying peak hours, and analyzing visitor patterns, mall management can implement effective strategies to optimize sales, allocate resources efficiently, and provide an unparalleled customer experience.

Decision-making Support: The accurate and real-time data from the bidirectional counter was a valuable tool for data-driven decision-making. Mall management could make informed choices to enhance operations and customer experiences.

The main contribution lies in reaffirming the importance of bidirectional visitor counters, especially in commercial establishments like malls and shopping centers. It stresses the benefits of leveraging these systems to optimize operations, enhance customer experiences, and make data-driven decisions for sustained success in a dynamic retail environment. This research was conducted between [10/9/2021] and [10/5/2022], aligning with the ongoing advancements in Arduino technology and its applications in visitor tracking systems and support Decision marketing and improved visitor experience."

This paper is arranged into sections: section 2 includes literature reviews for the bi-directional counter, section 3 consists of tools and methods used to design a bidirectional counter, section 4 presents the results for the bidirectional counter, section 5 discusses the benefits and challenges of the bidirectional counter, section 6 conclude this paper by showing the importance of this system and the future direction for applying bidirectional counter and merging it with the internet of things and machine learning applications.

Literature Review

Modern technology is on the rise like never before. It dramatically eases human life by streamlining our way of living. It altered communication systems, product manufacturing

methods, transportation modes, and people's knowledge and ideas. There is interest in using vision technology to show all types of settings. Resource management, urban planning, security, and advertising are just a few benefits of this. Technology-wise, computer vision solutions always involve using a CPU for detecting, transmitting, and analyzing [1]. A counter at the gate that counts how many individuals are there is part of an intelligent system. This system is also responsible for determining the direction of each moving object, such as when approaching or leaving a site [2]. Numerous facets of life call for counting items that come in and go out. Examples of these applications abound, including the interest of retailers in the volume of patrons entering or leaving their markets or malls over time. To manage parking availability, a garage owner must know how many cars enter and exit his garage and the number of elevator users. For instance, the volume of people and moving vehicles on any street and block can be utilized to control the traffic center and avoid traffic bottlenecks in Baghdad or any other large city where traffic jams are constant [3].

The authors of [4,5] suggested that people work on a project to make a system that automatically adjusts the room's lighting and temperature based on the number of occupants. The number of people in the room affects work temperature and light management. In contrast to others; [6]'s method of controlling fans relies on mobile Wi-Fi. [7] Internet of Things (IoT) devices, smart cameras, ultrasonic sensors, motion sensors, and microcontrollers were deployed to reduce traffic congestion on these roads. On the other side, laser radiation and door alarms are also employed to count people, although they may be expensive, according to our research [8]. While some work [9,10] to make life as simple as possible, keep their tasks simple. We use fans and lights to reduce electricity costs based on the number of people. [11-13] Build ultrasonic sensor networks to boost system reliability and, consequently, system complexity. While existing systems have highlighted the concept of bidirectional visitor counting, this research presents unique contributions and enhancements that set it apart from the previously mentioned source. The proposed system employs an Arduino NANO microcontroller, IR sensor modules, and a 16x2 LCD display module to achieve accurate and real-time bidirectional visitor counting. Unlike manual hand counters or simpler systems, this research introduces advanced features that enhance accuracy, reliability, and data visualization.

Methodology

The methodology outlines the design and implementation of a simplified bidirectional visitor counter (BVC) for tracking the number of people entering and exiting specific areas or stores within a commercial center. The BVC aims to provide valuable data to marketers, enabling them to understand foot traffic patterns and customer flow and assess the effectiveness of marketing strategies in converting foot traffic into sales. In Fig 2. a flow chart represents the bidirectional visitor counter.

1. Design and Hardware Setup:

- a. **Sensor Placement:** To accurately track the movement of visitors, infrared or other suitable sensors are strategically placed at entry and exit points of each area or store in the commercial center.
- b. **Data Collection Unit:** A data collection unit is installed near the sensors to record and process the signals generated by the sensors.

- c. Embedded System: The BVC system employs an embedded system, a combination of microcontrollers and digital signal processing components, to handle data acquisition and processing.

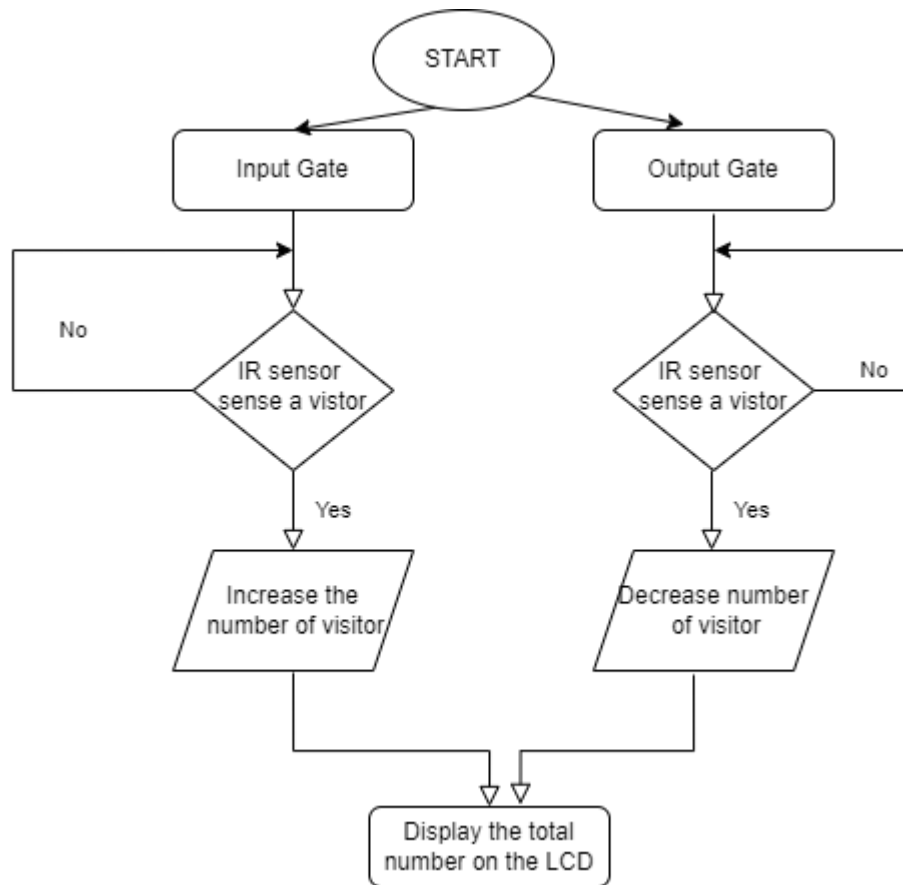


Fig. 2 Flow chart of the Bi-direction Visitor Counter

2. Data Collection and Processing:

- Sensor Activation:** When a person enters or exits a designated area, the corresponding sensor detects the motion and generates a signal.
- Signal Interpretation:** The data collection unit interprets the signals, distinguishing between entries and exits, and maintains an accurate count of the bidirectional foot traffic.

3. Data Storage and Analysis:

- Data Storage:** The BVC system stores the collected data in a secure and centralized database, ensuring the preservation of visitor count records.
- Conversion Rate Calculation:** Marketers use the recorded data to calculate conversion rates for each area or store by comparing the number of people entering with the number of purchases made in that location.

4. Marketing Insights and Optimization:

- Identifying Popular Zones:** Marketers can identify high-traffic and popular zones within the commercial center by analyzing the foot traffic data.
- Assessing Marketing Effectiveness:** Conversion rates help assess the efficiency of marketing strategies in converting visitors into customers.

- c. **Optimizing Strategies:** Marketers can analyze conversion rates across different areas and stores to optimize marketing strategies, promotions, and display arrangements for improved sales performance.

The BVC empowers marketers with valuable insights to optimize marketing strategies and improve sales performance, underscoring the significance of embedded systems in modern technology applications.

This project uses the Arduino Uno microcontroller, IR sensors, transistors, resistors, and LCD.

1) Tools:

Hardware Components

- **Microcontroller (ARDUINO UNO):** a board for a microcontroller that uses the ATmega328P. It comes with everything required to support the microcontroller; to use it, plug in a USB cable, an AC-to-DC adapter, or a battery to power it. The microcontroller has a crystal oscillator, serial communication, and a voltage regulator. The Arduino Uno has a USB connection, a Power barrel connector, an ICSP header, six analog input pins, 14 digital input/output pins, 6 of which can be used as PWM outputs, and other features [14]. Figure 3 illustrates an Arduino Uno in action. Arduino UNO was chosen because it provides a user-friendly platform, making it easier for those new to microcontrollers and embedded systems to understand and work with. Arduino has a massive and active community of users, developers, and enthusiasts worldwide. This community aspect can be advantageous for the authors as they can find many tutorials, guides, and open-source projects related to Arduino UNO. This microcontroller's computational capabilities enable the precise calculation and tracking of visitors, eliminating the potential for human errors. The system's robust algorithm tallies the total number of entering and exiting visitors and calculates the real-time count of visitors present within the space. Integrating a 16x2 LCD provides an intuitive way to visualize the visitor counts, making it accessible and understandable for users and stakeholders.



Fig. 3 *Arduino UNO*

- An electrical device that monitors and detects infrared radiation in its environment is an infrared sensor (IR). Both in industry and in daily life, infrared technology is used for a range of tasks. Low power consumption, straightforward design, and valuable features are the main benefits of IR sensors. IR signals are invisible to the unaided eye. IR radiation can be detected in the visible microwave area in the electromagnetic spectrum. Usually, the wavelengths of these waves range in the visible microwave region of the electromagnetic spectrum, and IR radiation can be

seen. These waves typically have wavelengths between 0.7 μm and 1000 μm . The three parts of the IR spectrum are the near-infrared, mid-infrared, and far-infrared ranges. Wavelengths range from 0.75-3 meters in the near-infrared region, 3-6 meters in the mid-infrared region, and more than 6 meters in the far-infrared area. VCC, GND, and Out are the three pins of an IR sensor. A distance adjustment potentiometer is also included. A distance adjustment potentiometer is also included. An example of an IR sensor is shown in Fig. 4.



Fig. 4 *IR sensor*

Dual Sensor Configuration: Our design employs a dual IR sensor configuration for entry and exit points. This enhances the precision of visitor tracking and prevents errors arising from individuals moving back and forth in quick succession.

Interface to Communicate (I2C): this simple-to-use display module can simplify the display. Making can be made simpler by using it, allowing artists to concentrate on the crucial elements of their work.

- **Liquid Crystal Display (LCD):** The term "Liquid Crystal Display" (LCD) refers to a flat panel display, electronic visual display, or video display that takes advantage of liquid crystals' ability to modulate light. Liquid crystals do not directly emit light. Fig.5 a) displays an example of an I2C display, and b) an LCD is displayed as an example.



Figure 5. *a. I2C b. LCD*

Real-time Data Handling: We've implemented interrupt-driven data handling mechanisms within the microcontroller to ensure real-time data accuracy. This approach minimizes data loss and latency, enabling rapid response to visitor movement.

Software Development

Arduino Integrated Development Environment (IDE) is shown in Figure 9. It comprises a toolbar at the top, a code window in the middle, and a serial output window at the bottom. Alternatively, a group of tabs with the code's filename might exist. The very far right side of the screen has one more button. The toolbar has a check next to it and comprises five buttons. The file menu is at the top and features drop-down menus with the headings File,

Edit, Sketch, Tools, and Help. As seen in Fig.6, the toolbar's buttons provide easy access to the frequently used options in the file menu.

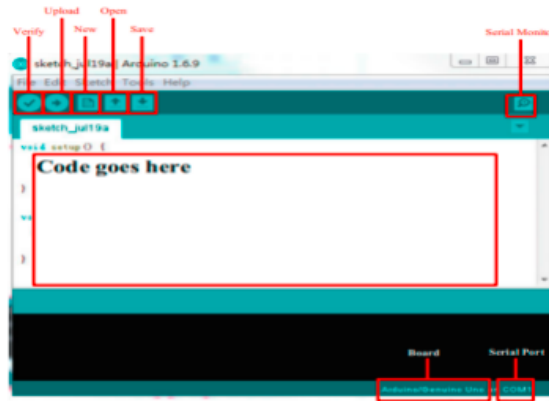


Fig 6. IDE software

2) Method

The system's brain is the Arduino Uno microcontroller. It must be configured with the necessary settings and libraries. Set up the board type and serial communication parameters for communicating with the LCD. The Arduino Uno should also be adequately powered via USB or an external power source. IR sensors are installed at the designated area's entry and exit points and placed the sensors so that they cover the desired detection range and have a clear line of sight with the passing people. They have adjusted the sensitivity and threshold settings for accurate detection depending on the IR sensor module used. It configures the LCD by initiating I2C communication and configuring the display parameters. Specify the rows and columns. Control the backlight and custom characters. Fig. 7 shows the diagram for the system. The Arduino Uno programming code is created. They are writing code to identify the direction of visitor movement and adjust the visitor count. Use appropriate conditional statements, variables, and control structures to implement the counting algorithm. The LCD is updated with the current visitor count after each detection event.

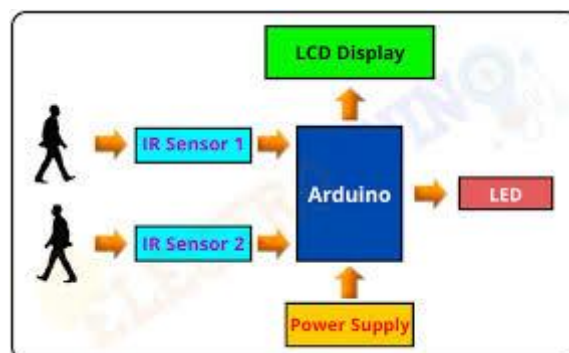


Fig. 7. The diagram for the BVC system

While the previously mentioned source focuses on the fundamental concept of bidirectional visitor counting, this research advances the methodology by leveraging Arduino technology. The Arduino NANO microcontroller is a central processing unit, enhancing accuracy and enabling advanced calculations. By utilizing Arduino technology, this research distinguishes itself through its ability to seamlessly integrate with other applications, potentially paving the way for IoT and machine learning integrations. This provides a more comprehensive and adaptable solution for modern visitor management needs. The successful development of our bidirectional visitor counting system has been driven by the integration of recent techniques, technologies, and tools that enhance its functionality, accuracy, and adaptability.

Results

This project is based on calculating the number of persons who enter and exit the gate. When a sensor is installed in the gate, the principle of this sensor (IR sensor) is that it detects infrared light. When individuals enter the gate, IR detects them and increases the counter by one. The converse is valid at the exit gate, where the sensor detects people and reduces the counter by one, table 1.

Table 1: Working Hours on Saturday

Sequence	Time	number of visitors
1	10 am	10
2	11 am	44
3	12 pm	50
4	1 pm	55
5	2 pm	58
6	3 pm	66
7	4 pm	88
8	5 pm	133
9	6 pm	145
10	7 pm	144
11	8 pm	122
12	9 pm	100
13	10 pm	30
14	11 pm	20

In this way, offers for some commodities can be displayed and identified at 10 am to balance the number of visitors during all working hours, as shown in Figure 10. The rush times are (4 pm, 6 pm, and 8 pm), while the idle times are (10 am, 11 am, and 10 pm). They can balance the number of visitors during idle time by evaluating the data. Moreover, the results shown in Table 2 were obtained by monitoring the number of Sunday visitors.

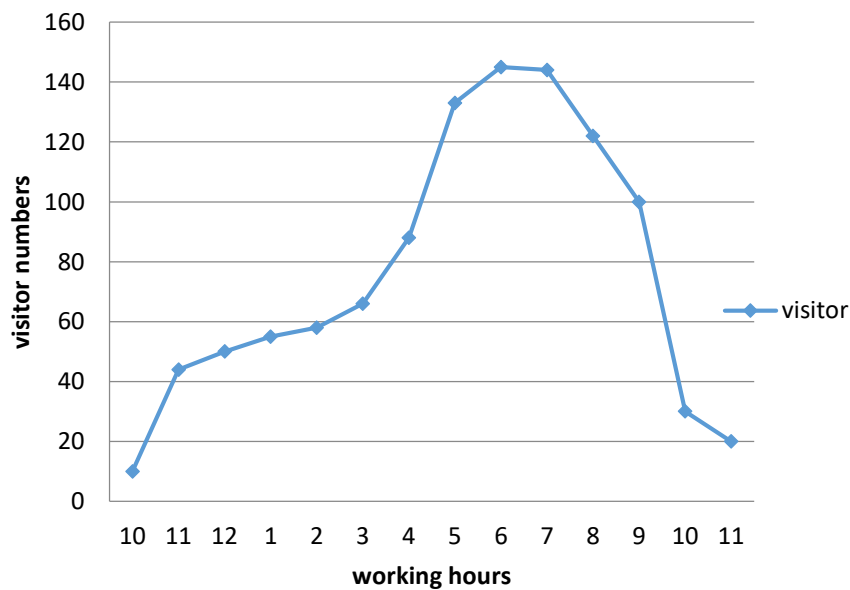


FIG 7. Visitors number on Saturday

Table 2: Working hours on sunday

Sequence	Time	number of visitors
1	10 am	8
2	11 am	37
3	12 pm	43
4	1 pm	49
5	2 pm	58
6	3 pm	66
7	4 pm	72
8	5 pm	77
9	6 pm	95
10	7 pm	102
11	8 pm	104
12	9 pm	99
13	10 pm	30
14	11 pm	22

It was concluded that the number of visitors is large during holidays and during the hours (4-8 pm) so that the management of the shopping center can balance the offers of goods and the working hours in which the number of visitors was concluded shown in Fig. 8.

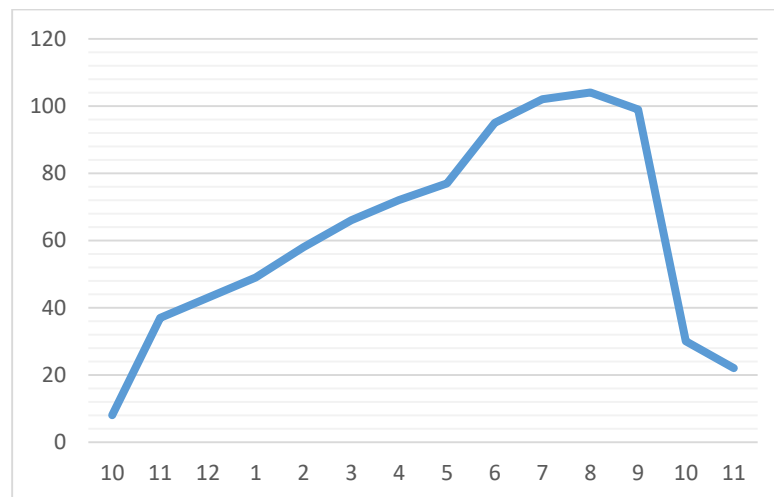
**FIG 8. Visitors number on Sunday**

Table 3 shows the number of visitors to the mall during the days of the week. Fig. 9 presents the idle hours in the mall are 10 am on all weekdays, 1 pm on Monday, Tuesday, Friday, and 2 pm during all days of the week, so special offers may be present at these hours to attract the most significant number of visitors and achieve the highest sales during working hours.

Table 3: Working hours throughout a week

	Sat	Sun	Mon	Tus	Wen	Thu	Fri	number of visitors
10 am	10	8	2	3	4	5	7	8
11 am	44	37	27	25	28	30	33	37
12 pm	50	43	33	34	35	38	22	43

1 pm	55	49	31	33	34	40	31	49
2 pm	58	58	33	34	35	37	38	58
3 pm	66	66	56	54	69	52	55	66
4 pm	88	72	68	70	75	71	77	72
5 pm	133	77	79	78	93	73	78	77
6 pm	145	95	91	92	93	94	88	88
7 pm	144	102	99	103	104	105	100	100
8 pm	122	104	103	99	102	110	111	122
9 pm	100	99	98	97	99	94	93	100
10 pm	30	30	29	23	27	28	29	30
11 pm	20	22	23	21	24	20	25	20

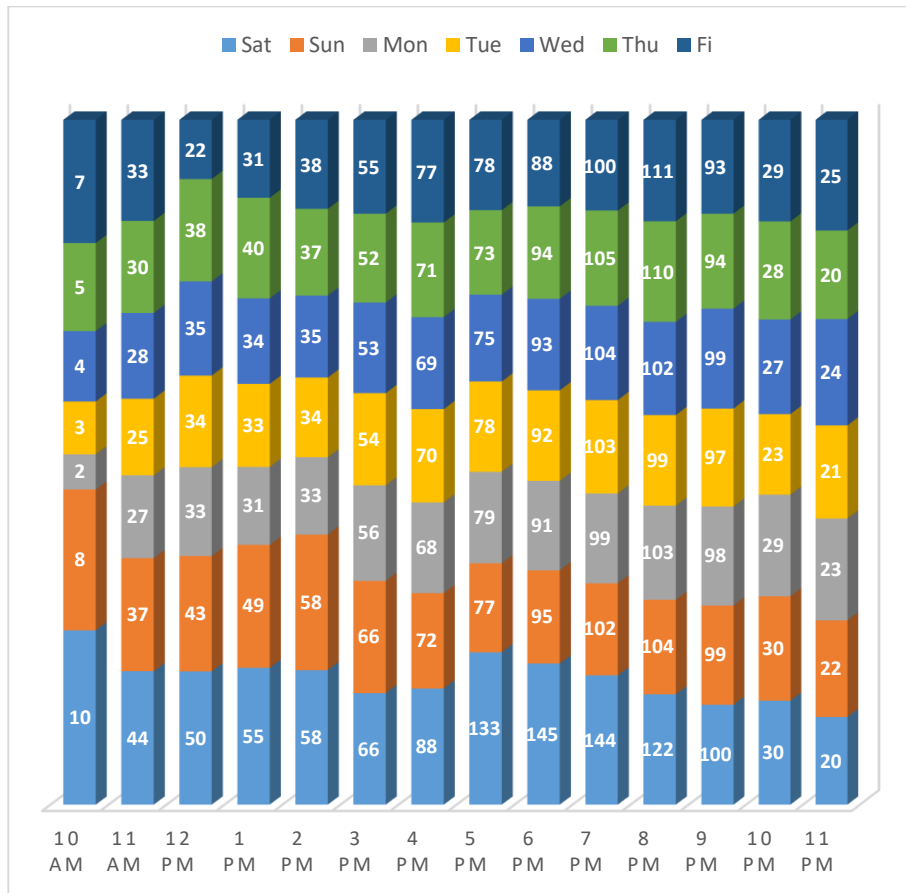


FIG 9. Visitor numbers throughout the week

Discussion

The paper's primary objective in [15] is to develop and implement a unidirectional digital visitor counter utilizing Bluetooth and FPGA technology. The proposed design uses an IR sensor to detect the entry of a person, and this IR sensor is remotely controlled through the Arduino Bluetooth control app. The research is divided into three essential parts:

- **Detection of Person Entry:** The first part focuses on detecting the entry of a person into the room using the IR sensor, which can be controlled remotely via the Arduino Bluetooth control app.
- **Increasing Person Count:** The second part involves incrementing the count of people in the room whenever the IR sensor detects a person's entry.

- **Displaying Count on Android Mobile:** The third part centers around displaying the count of people in the room on an Android mobile phone using the Arduino Serial Bluetooth Terminal app.
- The intended application of the unidirectional digital visitor counter includes settings such as Seminar Halls, Conference Rooms, Examination Halls, Community Halls, Classrooms, and private and public offices.

The paper[16] describes a circuit for controlling room lights based on the number of people in the room while also functioning as a security system with an attached camera. It increments the counter when someone enters the room, turns on LED lights, decrements the counter when someone exits, and switches off the lights when the room is vacant. The number of LEDs corresponds to the total number of people inside, and the count is displayed.

This research focuses on bidirectional counters as electronic devices or systems that track and count people entering and exiting a space. It highlights the significance of bidirectional counters in marketing and sales contexts for understanding customer behavior, optimizing strategies, and enhancing overall performance. The paper explores the design of a bidirectional counter application, emphasizing its impact on marketing and sales through visitor tracking, conversion rates, and visitor patterns. The potential of bidirectional counters as tools for data-driven decision-making, improved customer experiences, effective marketing strategies, and increased profits is underscored.

Bidirectional visitor counters provide malls and shopping centers with numerous benefits and applications, including improved customer service, optimized staffing, enhanced security, efficient tenant management, and targeted marketing strategies. Also, implementing bidirectional visitor counters in malls and shopping centers presents several challenges, including accuracy and calibration, privacy concerns, environmental considerations, and integration with existing infrastructure.

Advantages of Bidirectional Visitor Counter:

- **Accurate Data:** A bidirectional visitor counter can provide more accurate data than unidirectional counters. It can track entries and exits, giving a comprehensive view of visitor traffic.
- **Peak Hour Identification:** Bidirectional counters can accurately identify peak hours and busy periods. This information allows marketers to allocate staff and resources effectively during high-traffic times.
- **In-depth Analysis:** With bidirectional counting, marketers can analyze visitor patterns, dwell times, and repeat visits. This data helps understand customer behavior and preferences, enabling targeted marketing strategies.
- **Conversion Rate Calculation:** With data on both entries and exits, marketers can calculate the conversion rate - the percentage of visitors who purchase. This metric helps in assessing the store's performance and marketing effectiveness.

Disadvantages of Bidirectional Visitor Counter:

- **Cost:** Bidirectional visitor counting systems are generally more expensive than unidirectional ones due to the complexity of tracking both directions.
- **Privacy Concerns:** In some regions, bidirectional counters may raise privacy concerns as they can track individual movement within a space.
- **Technical Limitations:** In complex environments with multiple entrances and exits close together, bidirectional counters may face challenges in distinguishing individual paths accurately.

- **Data Interpretation:** Analyzing bidirectional data can be more complex than unidirectional data, as it involves interpreting entry and exit patterns and correlating them with other variables.
- **Maintenance:** Bidirectional counters may require regular maintenance and calibration to ensure continuous accuracy, adding to operational costs.

In summary, bidirectional visitor counters offer valuable data and insights for marketing purposes, enabling better decision-making and optimization of resources. However, they come with challenges, including higher costs, installation complexities, and potential privacy concerns. Marketers must carefully weigh the benefits against the drawbacks and choose the most suitable counting system.

Conclusion

The investigation into bidirectional visitor counting systems has underscored their significance in optimizing operational efficiency and visitor management. By exploring various technologies like infrared sensors, thermal imaging, video analytics, Wi-Fi tracking, and Bluetooth beacons, it is evident that bidirectional counters offer a robust solution for accurate visitor tracking in both directions. Overcoming challenges like accuracy calibration, privacy concerns, and integration with existing infrastructure opens up opportunities for improved customer service, efficient tenant management, enhanced security measures, and targeted marketing strategies. Real-world case studies have validated the effectiveness of bidirectional visitor counting systems, reaffirming their value and practicality. Integrating emerging technologies such as machine learning and computer vision holds the potential for even greater accuracy and advanced analytics, facilitating seamless integration with IoT devices and intelligent building management systems.

In conclusion, this research underscores the importance of bidirectional visitor counting systems in enhancing operational efficiency and visitor experience. By leveraging Arduino technology, it introduces a refined and comprehensive approach beyond manual counting and simplistic designs. As a future direction, integrating this bidirectional counter with emerging technologies such as the Internet of Things (IoT) and machine learning could unlock even more significant potential for optimization and data-driven decision-making.

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الخلاصة:

توفر العدادات ثنائية الاتجاه ، أو الأجهزة الإلكترونية ، أو الأنظمة التي تتعقب وتحسب الأشخاص أو الكائنات التي تدخل وتخرج من مساحة معينة ، رؤية قيمة حول التطبيقات المختلفة. في التسويق والمبيعات ، تعتبر العدادات ثنائية الاتجاه ضرورية لفهم سلوك العملاء ، وتحسين الاستراتيجيات ، وتحسين الأداء العام. تبحث هذه الورقة في تصميم تطبيق بسيط للعداد ثنائي الاتجاه وتقييم تأثيره على التسويق والمبيعات. من خلال تتبع الزائرين ومعدلات التحويل وأنماط الزائرين ، تتيح العدادات ثنائية الاتجاه اتخاذ القرار المستند إلى البيانات وتحسين تجارب العملاء. تسلط الورقة الضوء على إمكانات العدادات ثنائية الاتجاه كأدوات قوية للمسوقين ومحترفي المبيعات ، وتعظيم فرص المبيعات وقيادة استراتيجيات التسويق الفعالة لإرضاء العملاء وزيادة الأرباح.

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الكلمات المفتاحية:

العداد ثنائي الاتجاه، تجارب العملاء
، اتخاذ القرار ، فرص المبيعات
، استراتيجيات التسويق.

معلومات المؤلف

الايمل:

الموبايل: