Design and construction of a crowd control system for a lecture theatre

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ABSTRACT

This project designed and constructed a Wi-Fi controlled dual tripod turnstile for a lecture theatre's crowd control system. This was with a view to eliminating cases of rowdiness that usually occurs before, during and after lectures. The operations of a Wi-Fi controlled tripod turnstile system was implemented to include the unlock state, lock state and the emergency modes. The lock and unlock functions applies to every entry and exit doors in order to allow users to have complete control of the entire system. In addition, the emergency mode function was designed to allow movement out of the lecture theatre via two (2) entry and two (2) exit doors simultaneously. The results obtained show that an average of about 120 students per minute could enter and exit the lecture theatre via the system; Lectures for every hour is clocked to 55 min, this is to allow the students and Lecturers exit within 5 min to give room for an incoming lecture. The implementation of a crowd control system in large lecture theatre is of utmost importance in order to prevent disorderliness, crowd crushes and other factors affecting student's safety by designating entry and exit points in every lecture theatre and setting up a crowd control system with flexible access control in every lecture theatre.

Key words: Wi-Fi, Tripod turnstile, access controller.

INTRODUCTION

In recent years, there has been an increased case of theft, rowdy sessions, disruption of an ongoing lectures and in extreme cases the damage to lecture theatre fittings (Doors and Furniture). This is largely due to undesignated entry and exit points to the lecture theatre, leading to forced entry and exit in the lecture theatres. Also, limited seats available to students, poor and inadequate teaching aids, increased students population without increased and improved learning facilities etc, have also contributed to the problem (Akande and Ikibe, 2018).

A crowd control system is a public security practice where large crowds are managed to prevent the outbreak of stampede. Effective crowd control management is about managing expected and unexpected crowd occurrences. This can involve privately hired security guards as well as police officers (Benedictus, 2015).

Crowd control is often used at large, public gathering lsuch as street fairs, music festivals, stadiums and public demonstrations (Sanders, 2005).

Crowd control restricts an individual's movement and leads to a reduction in chaos as the crowd becomes denser (Environmental Protection Agency, 2007). The design for this project would make use of a Wi-Fi controlled dual tripod turnstile that allows access to two students at a time, hence reducing the forced entry and exit of students in lecture theatres. A proposed time frame for the transition for entry and exit is 3 to 5 min.

The first use of crowd control started in 1920, about 10 police officers would line-up side by side controlling crowd for important occasions; it advanced to the use of anti-riot patrol team equipped with Baton and riot shields. The turnstile was initially designed to allow humans to pass through while keeping livestock. The application of a turnstile for modern use was credited to Clarence Saunders who implemented it in his piggy Wiggly Shop.

MATERIAL AND METHODS

Tripod turnstile

The Tripod turnstile will be mounted at the various designated Entry and Exit doors, and it would be controlled
from the Android Software developed for it through a Micro-Processor which interfaces with the Tripod turnstile model, its configuration to open in a singular direction.

The tripod turnstile for this project was designed with Rhinoceros (3-D design Software) with (182.00 mm * 32 mm * 70 mm) dimension as shown in Figure 2, it consists of 11 parts which is assembled to complete the design. A 3D printing machine was used to complete the printing of the model, four(4) sets of the tripod turnstile were printed to serve as barrier for a lecture theatre with two entries and two exits. The logic states Zero (0) represents the unlocked State; no controls on the tripod turnstile function, while logic state one (1) represents the locked state as shown in Table 1.

### Table 1: Operation states of the tripod turnstile.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Entry door</th>
<th>Exit door</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0</td>
<td>0</td>
<td>Initial State (locked state)</td>
</tr>
<tr>
<td>2.</td>
<td>0</td>
<td>1</td>
<td>Exit Door is Unlocked</td>
</tr>
<tr>
<td>3.</td>
<td>1</td>
<td>0</td>
<td>Entry Door is Unlocked</td>
</tr>
<tr>
<td>4.</td>
<td>1</td>
<td>1</td>
<td>Both doors are Unlocked</td>
</tr>
<tr>
<td>5.</td>
<td>1</td>
<td>1</td>
<td>Emergency situations, every designated doors opens outwards, that is, Health Emergency, Fire etc</td>
</tr>
</tbody>
</table>

### Solenoid

A linear solenoid shown in Figure 1 was used in this project; it converts electrical energy into a mechanical...
Figure 3: A NODEMCU microcontroller.

Table 2: Results obtained from the design.

<table>
<thead>
<tr>
<th>S/N</th>
<th>No. of users connected to the system.</th>
<th>Response time</th>
<th>Entry rate</th>
<th>Exit rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Entry action &lt; One second</td>
<td>Approximately 4 students for every two second</td>
<td>Approximately 4 students for every two second</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Exit action &lt; One Second</td>
<td>120 students/minute</td>
<td>120 students/minute</td>
</tr>
</tbody>
</table>

pushing or pulling force or motion. A push-pull solenoid is used for the design of the project; when the coil is powered, the armature is pulled into the center of the coil. This allows the solenoid to pull (from one end) or push from another, each of the solenoids has a power rating of 12 V @ 0.73 A, which is equivalent to 8.76 W.

Microcontroller firmware

The microcontroller firmware is based on a simple trigger to turn-on/off the digital outputs, which consequently turn on/off the solenoid. A NODEMCU microcontroller with inbuilt Wi-Fi device is deployed (Figure 3). A webpage and other program functions were uploaded to the microcontroller to control the device.

RESULTS AND DISCUSSION

Regarding the response of the system to the number of users, the response time for the system and the average number of student entry and exit per minute, the response time is between 500 to 800 min indicating a fast response time from the access controller to the tripod turnstile. The data obtained were from (Therapod Seating Solution, 2016). Table 2 shows that an average flow rate for a singular TS1022/S Model is 25-48 pass/minute. Also, it takes two (2) seconds for a tripod turnstile arm to rotate 120° for every entry or exit.

The prototype designed for this project demonstrates the use of a dual tripod turnstile in preventing stampede, surge of students entering and leaving a lecture theatre, reduce disorderliness and acts that may put the lives of students in danger.

The tripod turnstile model was designed using Rhinoceros 3D design software and was printed with a 3D machine which is divided into eleven parts to be assembled (Figure 4). It consists of two push-pull solenoids which aids movements in both directions and blocked movement in reverse direction for an exit or entry door. The flow rate as shown above explains the average number of students entering and exiting the lecture theatre. For a student population of 300 (Three hundred), it will take an average time of Three minutes for students to enter into the lecture theatre before lecture commences. Therefore, a lecture for every hour using this system is clocked to 55 min. This is to allow the students and lecturers exit within 5 min to give room for an incoming Lecture; thus, creating a smooth transition from one lecture hour to another. The Entry rate calculated depends also on the number of entry/exit doors available in a lecture theatre; as the number of Entry/Exit door increase, the Student entry/exit rate increases.

The use of this tripod turnstile allows only two student entry at the same time for every designated entry and exit points. This implementation reduces the disorderliness in
which students enters and leave lecture theatres which might lead to decrease in damage of lecture theatre furniture, stampede, disorderliness, accidents and other acts posing risk to lives of the student. The device is controlled via mobile software as shown in Figure 5, with a micro-controller to control the operations of the system.
The constructed lecture theatre model with the tripod turnstile barriers is shown in Figure 6.

**CONCLUSION**

The implementation of a crowd control system in Lecture theatre with large capacity is of utmost importance to prevent disorderliness, crowd crushes and other factors affecting students' safety by designating an entry and exit point in every lecture theatre and setting up a crowd control system with access control in every lecture theatre. A Wi-Fi dual tripod turnstile was designed and constructed to reduce the surge and disorderliness of students entering and leaving a lecture theatre, rowdiness that might occur due to transition from one lecture class to another and also create an orderly arrangement of how students enter or leave the lecture theatre. In addition, it was able to identify the cause of problems arising with students surge into lecture theatre and also ways to reduce the menace in lecture theatre in regions with very high student populations around the world.

**REFERENCES**


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