RIDR Model for Crowd Management using RFID Technology

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Abstract: - In many religious events, there are many *crowd crush disasters* have occurred, as in 2015 *Mina* stamped. In this work we devolved the model "*Real Time Information Density and Density Rate*" (RIDR). Using Radio Frequency Technology with the "*RIDR*" model enable the *crowd management center* to control all paths and places of the event, collect real time information about *state variables* of the zones as population, population rate, density and density rate. The system can predict any zone that exceeds the critical density to take a corrective action. The model helps the control system to predict a crush on any intersection between two paths (streets). It is possible to integrate the RIDR model with modern traffic system to give some suitable control action as traffic light and roads signals. This method is characterized by accurate calculation of state variables in comparison with methods of surveillance cameras system, so that accurate state variables can be used to apply modern control systems.

Key-Words: Crowd Management, crush, stampede, real time, Radio Frequency, Control System

1 Introduction

On 24 September 2015 an event described as a "crush and stampede"[1] caused deaths estimated at well over 2,000 pilgrims, suffocated or crushed during the annual Hajj pilgrimage in Mina, Mecca, Saudi Arabia.

The high number of deaths caused by the disaster make it the deadliest Hajj disaster in history [1][2][3]. Estimates of the number of dead vary; the Associated Press reported 2,411 dead [4][5], while Agency France-Presse reported 2,236 killed[6].

The crush took place in Mina at the intersection of streets 204 and 223 leading up to Jamaraat Bridge [7].

A number of Hajj-related crowd crush disasters have occurred in the past [8]. with 1,426 people being suffocated and trampled to death in a 1990 tunnel tragedy, and at least 701 people killed in crowd crushes between 1991 and 2005[9]. 346 people were killed in a similar Jamaraat incident in 2006, which prompted the Saudi government to improve the infrastructure of the city and its procession routes [10].

The Saudi Arabian government has been spending $60 billion to expand the Grand Mosque which houses the Kaaba, and has deployed 100,000 security forces and 5,000 CCTV cameras to monitor the crowds [11]. The Saudis have also built a permanent tent city in the Mina valley. It is covered with approximately 160,000 air conditioned tents across multiple campsites (grouped by nationality) for use by Hajj pilgrims [12].

1.1 Human Stampedes and Crushes

Human stampedes and crushes often occur during religious pilgrimages [13] and professional sporting and music events, as these events tend to involve many people in a dense area (overcrowded). They also occur in times of panic (e.g. as a result of a fire or explosion) as people try to get away [14].

1.1.1 Stampedes

According to experts, true "stampedes" (and "panics") rarely occur except when many people are fleeing in fear, such as from a fire [15], and trampling by people in such "stampede" conditions rarely causes fatal injuries [16].

1.1.2 Crushes

Crushes are very often referred to as stampedes but, unlike true stampedes, they can cause many deaths. Crowd density is more important than size. A density

of four people per square meter begins to be dangerous, even if the crowd is not very large.

Academic experts who study crowd movements and crushing disasters oppose the use of the term "stampede"[16]. "The rhetoric of 'stampede' is often used to imply that the crowd is animalistic or mindless", Most reported "stampedes" are better understood as "progressive crowd collapses"[16][17]. beginning at densities of about six[16] or seven[15] persons per square meter, individuals are pressed so closely against each other they are unable to move as individuals, and shockwaves can travel through a crowd which, at such densities, behaves somewhat like a fluid[15].

1.1.3 Why this Solution

The camera system cannot provide a complete solution to the problem but may be an aid. The best solution to this problem should be a digital control system (as Model Prediction system) that allows control and prediction. The most important of these is the real time monitoring of state variables, using smart devices as RFID and RIDR model which is presented in this paper.

2 The Fist Model of Crowd Disasters

A simple model with the acronym "FIST" is proposed to provide a basic understanding of crowd disasters [18]. The acronym elements are defined as the
crowd Force or crowd pressure (F); the Information (I) upon which the crowd acts; the physical Space (S) involved, both in terms of individual density and larger scale architectural features; and Time (T), the duration of the incident. The model is used to illustrate crowd characteristics and to develop guidelines for the prevention of crowd disasters. It is concluded that real time information and communication are key factors in preventing crowd disasters [18].

2.1 Prevention of Crowd Disasters by Crowd Management

Most major crowd disasters can be prevented by simple crowd management strategies.
The primary crowd management objectives are the avoidance of critical crowd densities and the triggering of rapid group movement.

2.1.1 Crowd Management Center

Real time information about the status of crowd conditions in large assembly spaces is critical. A centralized crowd management and communications center should be set up for this purpose. The ideal center would provide a maximum view of the venue, supplemented by video camera access to blind spaces, pressure points, and major movement pathways.

3 The RFID Technology and Its Current Applications

RFID is only one of numerous technologies grouped under the term Automatic Identification (Auto ID).

The RFID technology is a means of gathering data about a certain item without the need of touching or seeing the data carrier, through the use of inductive coupling or electromagnetic waves. The data carrier is a microchip attached to an antenna (together called transponder or tag), the latter enabling the chip to transmit information to a reader (or transceiver) within a given range, which can forward the information to a host computer. The middleware (software for reading and writing tags) and the tag can be enhanced by data encryption for security-critical application at an extra cost, and anti-collision algorithms may be implemented for the tags if several of them are to be read simultaneously [19].

One important feature enabling RFID for tracking objects is its capability to provide unique identification. One possible approach to item identification is the EPC (Electronic Product Code) [20].

3.1 Types of Tags

RFID tags can be grouped under a number of categories.

Passive Tag: Obtains operating power from the reader, the reader sends electromagnetic waves that induce current in the tag’s antenna, the tag reflects the RF signal transmitted and adds information by modulating the reflected signal.

Active Tag: Powered by an internal battery, used to run the microchip’s circuitry and to broadcast a signal to the reader generally ensures a longer read range than passive tags. More expensive than passive tags

(especial because usually are read/write), the batteries must be replaced periodically.

4 Real Time Information Density and Rate of Density (RIDR) Model

4.1 THE Concept of Solution

The main idea of the concept is to use the RFID technology or any smart device to give real time information about the density and density rate of roads, places and Grand Mosques during pilgrim, where every pilgrim holds a smart card (Identification tag).

4.2 Identification Tag Attributes

The identification tag contains the following attributes:
Id no (primary key), Pass No, country, First Name, Last Name, Birthday and City.

4.3 Path Management

In the infrastructural of the control system, the paths must have a "path Id", and it must divided into Zones. Each zone has its identification No "zone Id". Each zone can have many radiofrequency readers also with its "Reader Id" so that the system can record any "Id No" which enters the zone. Fig.1 shows the idea of path planning and zone distribution, and how can the radio frequency readers cover the entrance of each zone. Readers R1, R2 and R3 are installed at the entrance of zone (I) and readers R4, R5 and R6 are also installed at the entrance of zone (I+1) and so on along the path.

4.4 How to Collect Zone Information

To count the population X_i of a zone for the pilgrim entering the zone. When any reader of the zone read a Tag Id the system search at first if the id is recorded in the zone, if not then the population of the zone I is $X_i = X_i + 1$

The rate of population ($\dot{X}_i$) of the zone I can be calculated each time interval Δt as

$$\dot{X}_i = \frac{X_i(t+\Delta t) - X_i(t)}{\Delta t} \qquad (1)$$

Also if the same Id entering (recorded in) the zone I+1 then

$X_i = X_i - 1$ and, $X_{i+1} = X_{i+1} + 1$

The density of the zone I equal the population divided by the zone area $D_i = \frac{X_i}{A_i}$ (2)

The rate of density ($\dot{D}_i$) of the zone I can be calculated each time interval Δt as

$$\dot{D}_i = \frac{D_i(t+\Delta t) - D_i(t)}{\Delta t} \qquad (3)$$

The system scan and store the paths and zones information each time interval in a system interface (xml file) containing the following attributes:
Time (time stamp), path id, zone id, population, population rate, density and density rate. We consider the following: Population X (I), population rate $\dot{X}$ (I), density D (I) and density rate $\dot{D}$ (I) as state variables of the zone (I),
Which enable the system to monitor and predict very important information to enable the control manager and the system to take a control action as

- When predict that some zones exceeds a critical density.
- Or when the system predict a crush on the intersection between two streets (paths).

The zone tag entity type is very important to collect individuals and groups information, which enable the system to monitor the following many events as:

- Monitor any obstacle made by some groups in the paths.
- Discover some trouble makers groups during the pilgrim.

5 Conclusion

The primary crowd management objectives are the avoidance of critical crowd densities and triggering of rapid group movement. The main idea in the RIDR model is to use the RFID technology or any smart media to collect real time information (state variables) about the event, to enable the system to act as Model Prediction controller. An identification tag is used for every individual. The infrastructural of the places are equipped by data reader so the system can scan and store information periodically and accurate calculate the state variable of the control system. Using Model Prediction Control (MPC) the system can take many control action. Naturally the corrective action depends on the infrastructure of the entire system. So it is possible to integrate the RIDR model with modern

traffic system to give some Suitable control action and display important information.

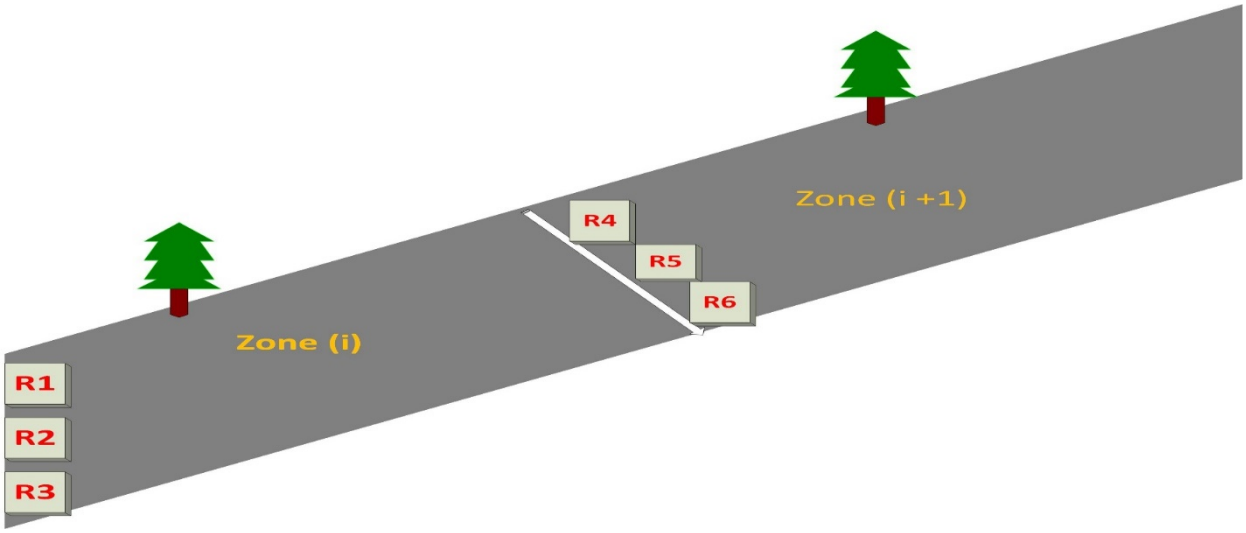

Fig.1 path planning, Zones and the reader's distributions at the entrance of each zone

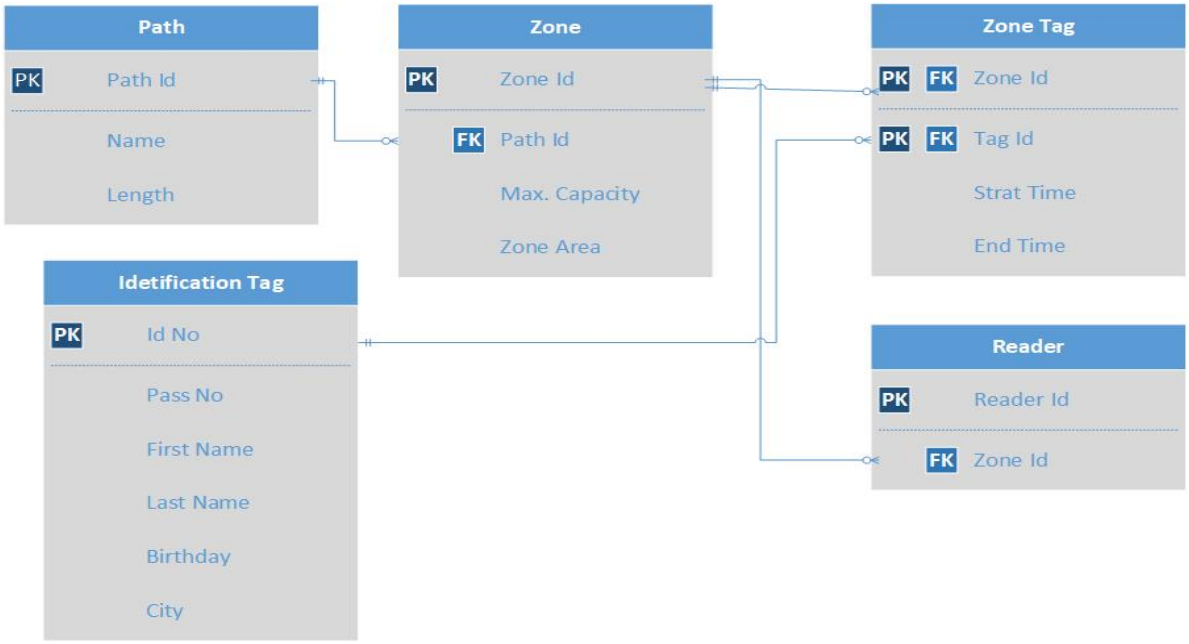

Fig. 2 ER Diagram of the main Entity types of the system

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