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# APPLYING THE ALFIL CROWD SIMULATOR TO A REAL EVACUATION INCIDENT: THE NEWS DIVINE SCENARIO

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**KEYWORDS**
Multi-agent systems, Crowd simulation, Personality modeling, Emergency response, Serious games

## ABSTRACT

This paper presents a reconstruction of the News Divine Discoteque, one of the most well-known and well-documented evacuation catastrophes in Mexico in recent years. A simulated evacuation is compared to the official reports using mean squared error and an error percentage.

## INTRODUCTION

The News Divine incident is without a doubt one of the most media-covered and well-documented evacuation tragedies in Mexico (BBC News 2008), (National Commission of Human Rights, México 2008a;b; 2009) and more recently (El Universal Online México 2011).
The fact that several recreations and investigations have taken place regarding this incident makes it a good referral for simulation evacuation. In this particular case, we are not trying to explain the causes of this tragic event, only to reproduce the events using the ALFIL model (García-García et al. 2012a).
The main difference with comercial evacuation software such as PEDSIM (PedSim 2002), Maya Crowd (Maya 2011), Golaem (Golaem 2013) or INCONTROL (INCONTROL 2013) is that ALFIL uses a personality-driven behavior model (García-García et al. 2011; 2012b) to simulate each individual.

## PROBLEM DESCRIPTION

According to the official report the evacuation progressed in three phases: in the first three minutes approximately 65 people left the building and were transported in the first bus, with no report of injuries; in the next three minutes approximately 65 more people were transported in a second bus, with no report of injuries; 6 minutes into the raid, and with no more buses available, the police locks the door, effectively containing the remaining people inside; eleven minutes into the raid, the police containment is relaxed and the doors are finally opened, finding 12 dead and 102 injured people; 27 minutes into the raid, a single ambulance will show up. Summarizing:

- Seconds 0 to 180: approx. 65 people evacuated, assuming 0 injured
- Seconds 181 to 360: approx. 65 more people evacuated, assuming 0 injured
- Seconds 361 to 660: assuming 0 people evacuated, 114 found injured
- Seconds 661 and onward: The police containment is relaxed and the doors are finally opened

## APPROACH

A virtual environment similar in size and distribution to the real venue of the incident was filled with 350 civilian agents, the approximate number of occupants in official reports (National Commission of Human Rights, México 2008a;b) and news sources (El Universal Online México 2011), with initial reports suggesting up to 500 occupants (BBC News 2008).
The artificial crowd was then evacuated under different scenarios to measure the evacuation time, speed of evacuation, number of injured, and number of dead; as well as the average presence of fear, and the number of people in panic.
Official regulatory sources (Pérez-Guerrero 2006) refer an evacuation time of 2.5 minutes (150 seconds) for 100 people using a 1 m door, assuming a walking speed of 1 m/s, or 0.67 people per second, or *pps*. Cross-cultural studies (Levine and Norenzayan 1999) place the average walking speed of a healthy adult at 1.4 m/s. Training materials refer an acceptable evacuation time of up to 3 minutes (UEPCYBJ 2012).
Using this model we estimate the required evacuation time for the venue described in the official report to be of 525 seconds or 8 minutes 45 seconds, due to the fact that it only has one door, and not the regulation-

mandated 1 door per 100 people for the target time of 2 minutes 30 seconds with 0.67 pps.

*Evacuation scenario as per the official report*
From the official report data, a very simple linear regression model was used to determine evacuation and injury rates. Figure 1 illustrates the amounts of evacuated and injured people over time and Figure 2 illustrates the evacuation and injury rates.

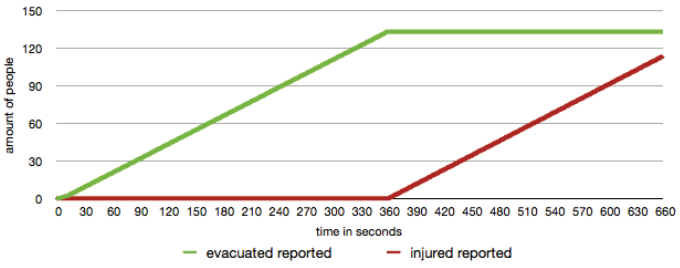


Figure 1: Evacuated and injured people according to the official report.

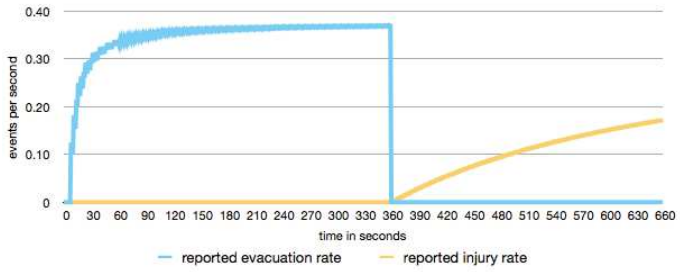


Figure 2: Evacuation and injury rate from a linear regression based in the official report.

*ALFIL simulation of the official scenario*
This scenario attempts to recreate the events in the report and is divided in two phases:

- Seconds 0 to 360: The doors are fully open and, while the police is directing the evacuation, there is no physical pressure to do so. An agent is considered evacuated when he crossed the door.
- Seconds 361 to 660: The doors are closed and the police officers are unaware of this fact, thus begin pushing the detainees. An agent who falls prone or who sustains too many collisions is considered injured.

We can observe from the simulated evacuation a total of 94 evacuations and 69 injuries. Figure 3 illustrates the amounts of evacuated and injured people over time. Figure 4 illustrates the evacuation and injury rates, with evacuation average of 0.55 and injury average of 0.09.

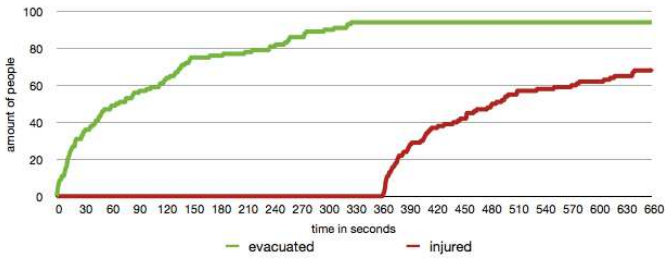


Figure 3: Evacuated and injured people from the ALFIL simulation.

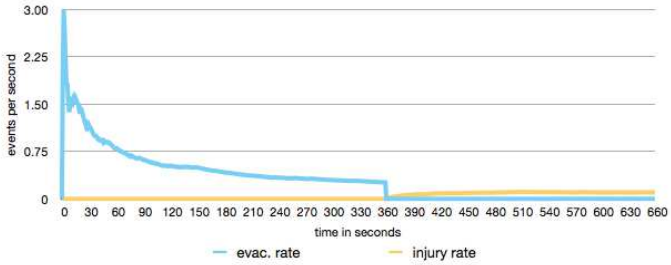


Figure 4: Evacuation and injury rate from the ALFIL simulation.

## RESULTS

We establish a comparison point between the linear regression from the report and the simulated amount of evacuated and injured people. A shown in Figure 5, both the evacuation and injury rate behave in a similar way, even if there is a clear difference between linear regression and simulation.

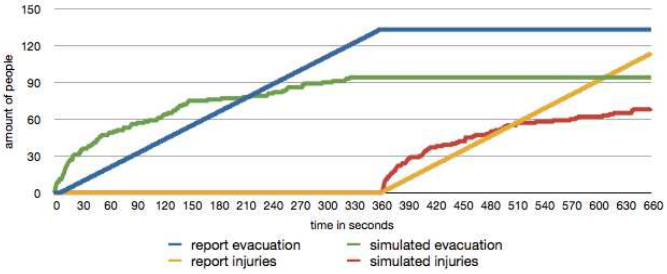


Figure 5: Evacuation and injury comparison from the report and simulation.

From this comparison we establish an accumulated mean squared error or *MSE*, which can serve as a comparison with other simulations of similar events. The accumulated MSE is shown in Figure 6 and clearly shows that the simulation rapidly loses accuracy and is unable to compensate for the accumulated errors.

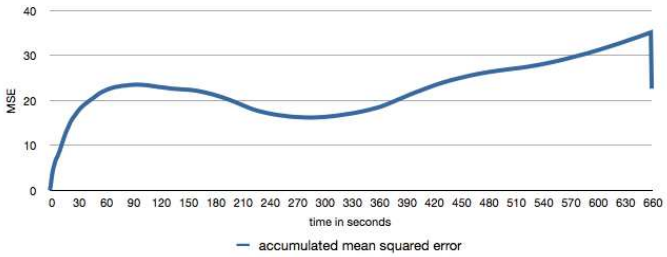


Figure 6: Mean squared error for the ALFIL simulation.

Finally, an error percentage and error percentage average is calculated for both evacuations and injuries. Figure 7 shows this result, with an average evacuation error of 32.74% and an average injury error of 34.50%.

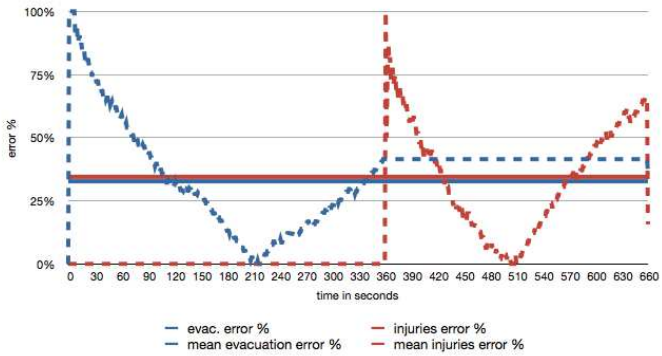


Figure 7: Error average percentage for the ALFIL simulation.

## CONCLUSIONS

First, we want to reproduce textually the conclusions reached by the official incident investigation by National Commission of Human Rights, México (2008a;b):

- The New's Divine venue operated illegally
- The police raid was badly planned
- The police raid was badly executed
- The consequences of the police raid where badly managed

We observe that the average evacuation speed of 0.55 *pps* in the simulated scenario suggests that the venue was probably over full capacity, closing in the estimated 8 minutes and 45 seconds and going beyond the regulatory 2 minutes and 30 seconds.
The evacuation speed of 0.37 pps, obtained from the official report's linear regression suggests that the evacuation was proceeding slowly, accounting to restricted movement by the police watching the doors.

While we are in no position to support or challenge the official findings, given that the physical venue no longer exists and that we had no access to official expert forensic reports; we can conclude that the behavior model used to simulate the evacuation produces results that are close to a 30% margin of error, which is the greatest error tolerable for simulation of socio-organizational phenomena.

### Further work

Data from this simulation will be used to further refine the ALFIL behavior model to improve its accuracy and reduce both the mean squared error and error percentage.

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