Author's Commentary: Time to Leave the Louvre

Michelle L. Isenhour
Operations Research Dept.
Naval Postgraduate School
Monterey, CA 93940
`mlisenho@nps.edu`

Introduction

Crowd evacuation and response to emergency situations is a relatively new and interesting research field. It is truly an interdisciplinary subject area, sitting at the intersection of mathematics, physics, civil engineering, fire safety engineering, computational science, and human psychology.

Conceptually, the process of evacuating a building is relatively simple: safely move individuals from inside of the building to outside. However, the process becomes significantly more intricate as building complexity and occupancy increase. Given a sizable building with a large number of occupants, the challenge to maintain order, ensure individual safety, and evacuate as quickly as possible becomes difficult.

From a mathematical standpoint, there is an abundance of macroscopic and microscopic evacuation models. These include

- network flow models;
- discrete microscopic models, such as the social force model, cellular automata model, particle-swarm optimization models, and agent-based models; and
- continuous macroscopic models, such as fluid dynamic models and gas-kinetic models [Zhou et al. 2018].

As is the case with most models, the simplicity or complexity of the model is determined solely by the application and implementation of the model.

A serious incident inside the building, such as a fire, chemical spill, or a terrorist attack, further complicates the evacuation process. Risk-management considerations must be made to assess the situation quickly

---

The UMAP Journal 40 (2–3) (2019) 161–163.

and determine impacts. Exits may be blocked, emergency personnel may need to respond, and the occupants may become unpredictable and/or panic.

Potential validation data from a routine fire drill in a student center was presented at the 2016 Pedestrian and Evacuation Dynamics conference at the University of Science and Technology in Hefei, China [Isenhour and Löhner 2017]. A routine fire drill in a modern building roughly 30,000 m^2 in size with fewer than 400 occupants took 9 min to evacuate. So it is reasonable to expect that a unique historical building such as the Louvre, which is more than twice that size, with limited egress points and many more occupants, would take much longer to evacuate, especially under conditions of duress.

Formulation and Intent of the Problem

The interdisciplinary nature of evacuation modeling, combined with the challenges of the most-visited in art museum in the world, in a city often targeted by terrorism, led directly to this year's Interdisciplinary Contest in Modeling (ICM™) problem "Time to Leave the Louvre."

The goal of the problem was for teams to develop interdisciplinary solutions that would allow museum emergency planners to explore a range of options, policies, and procedures to quickly and safely evacuate visitors from the museum.

From the outset, the problem challenged teams to model the building, the number and diversity of visitors, and the locations of exits. Using their evacuation models, the teams were asked to identify potential bottleneck (congestion) areas and consider how technology could be used to aid the evacuation process. The desired end result was a set of policy and procedural recommendations for emergency evacuation of the Louvre.

Evacuating the Louvre intentionally presented an ambiguous problem set. Since most teams would be unfamiliar with the Louvre, they would first need to determine the physical size and layout of the Louvre. Then they would need to determine an appropriate quantity, type, and distribution of museum occupants.

Following the determination of the inputs and implementation of the evacuation model, student teams were asked to use the model to explore alternative scenarios and provide policy and procedural recommendations to the management staff of the Louvre, as well as discuss the portability of their model to other similar structures.

Comments on the Results

Many teams opted to explore and implement some combination of the aforementioned evacuation models. The very best teams realistically modeled all five floors of the Louvre and used a single model to find reasonable total evacuation times under a variety of situations. Rather than focus on the model, they focused on *using* the model to conduct analysis and provide recommendations to the emergency planners, demonstrating how to use the model to make decisions.

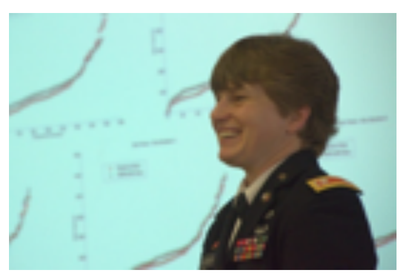
Although simulation of the evacuation was not explicitly required, many teams took the extra step and created a simulation of the evacuation, using software tools such as AnyLogic, QGIS, NetLogo, Pathfinder, BuildingXODUS, Exit89, and MATLAB. Used correctly, these 2D and 3D representations of the evacuation enhanced the understanding of the evacuation flow and helped teams identify the locations of potential bottlenecks. However, in most cases, the inclusion of an evacuation simulation did not enhance the paper, because the simulation tool used was often disconnected from the evacuation model previously described.

References

Isenhour, M.L., and R. Löhner. 2017. Validation data from the evacuation of a student center. *Collective Dynamics* 1: 472–479.

Zhou, M., H. Dong, B. Ning, and F.Y. Wang. 2018. Recent development in pedestrian and evacuation dynamics: Bibliographic analyses, collaboration patterns, and future directions. *IEEE Transactions on Computational Social Systems* 5 (4): 1034–1048.

About the Author



Michelle Isenhour is an Assistant Professor in the Operations Research Dept. at the Naval Postgraduate School in Monterey, CA where she teaches statistics and data analysis. Her research focuses on the microscopic modeling and simulation of pedestrians during evacuations and emergency scenarios, with a particular emphasis on pedestrian initial response to emergency and/or evacuation situations. Michelle holds a Ph.D. in Computational Science and Informatics from George Mason University and an M.S. in Applied Mathematics from Western Michigan University.