Crowd Evacuation: Unjamming with an Obstacle

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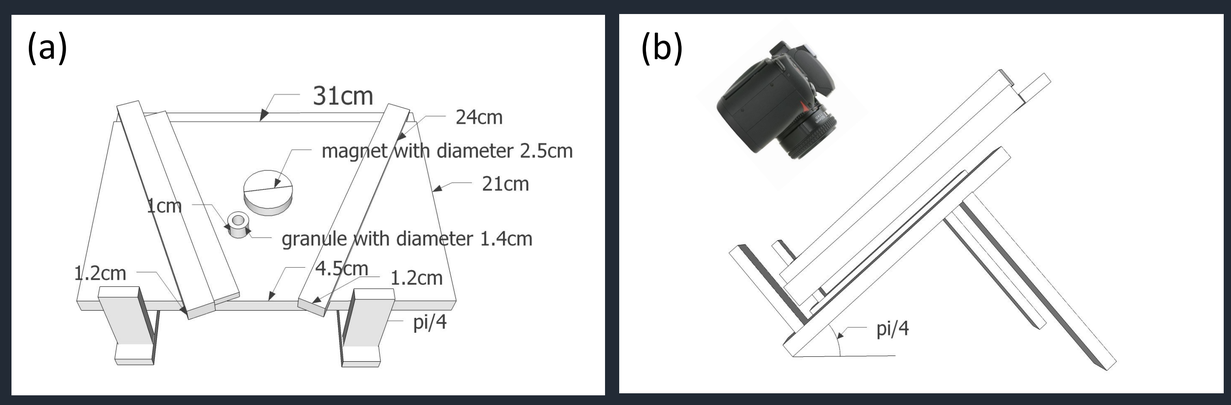
Introduction

An emergency exit experiment says that when there's an obstacle near the exit, an emergency evacuation (the upper picture) is faster than the case without an obstacle(the lower figure). We want to find out 1. the best position of obstacle for evacuation, 2. the dynamic explanation to the reason of jamming. [1]

Set-up

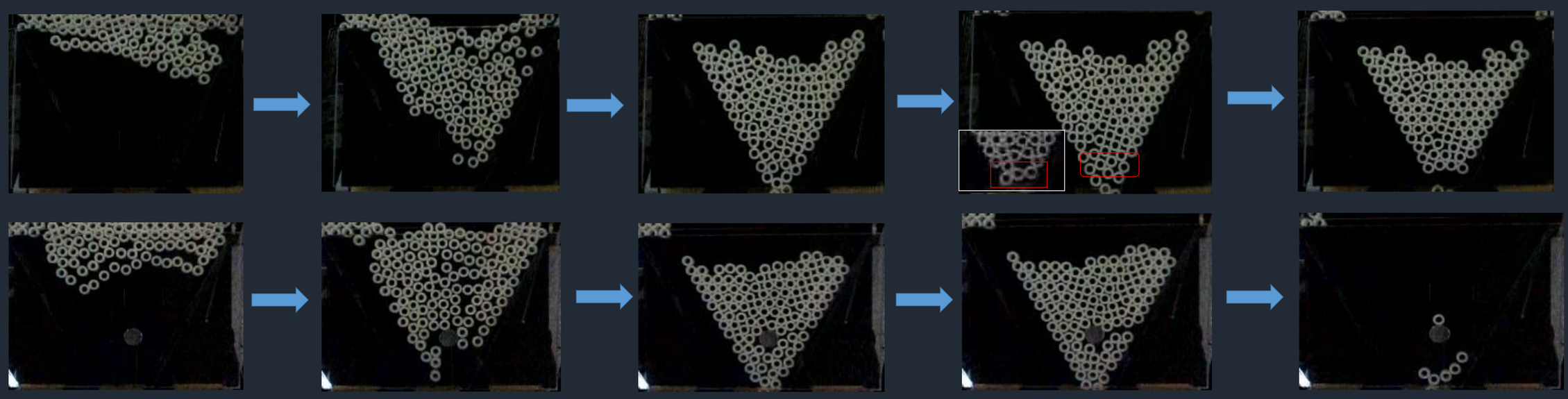


(a) The top view of our device.(basically made of Acrylic)
(b) The side view of our device.
(c) The granules we use. (made of Acrylonitrile butadiene styrene)

(c) 

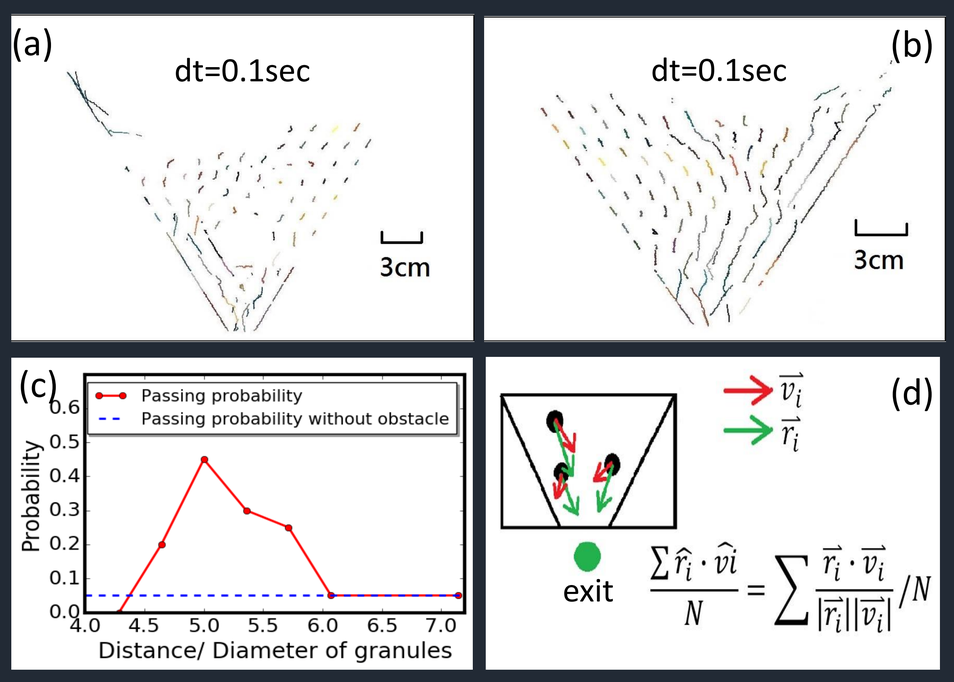
Experiment detail

(3)



t = 0.12 sec t = 0.21 sec t = 0.50 sec t = 0.55sec t = final

The configurations of granules in the box evolving with time. The upper row represents the condition that there's no obstacle in the box and granules eventually get stuck; the lower row represents the condition that there's an obstacle in the box and granules eventually flow out. The video is captured by camera with 480 fps. When the granules are stuck, usually three or four particles form an arc near the exit.



(a), (b) show the trajectory(use ImageJ with Mosaic plugin to get trajectories from video frames) of the condition that the granules "passing with obstacle" and "stuck without obstacle". (c) The plot of the probability of passing through vs. (distance of obstacle from exit) / (diameter of granule)(red dots), and the probability of passing through without obstacles(blue line). (d) shows the concept of our inner product method. (e), (f) show the value of mean square inner product of direction with time(computed from trajectories by Python), besides, we use a threshold setting as $\cos(\frac{\pi}{4})$ to determine if the granules tend to move toward the exit. The results are expressed as the red line. The value above threshold represents a more ordered situation, which leads to jamming; the value below threshold means a more disordered situation, and it can offer space for some granules to pass the exit smoothly. (g), (h) show the averaged percentile of not crossing over the threshold related to lasting time, the longer time that the inner product stays under threshold, the less tendency the granules running toward the exit. Thus it's beneficial to evacuation.

Conclusion

1. The splitting function of obstacle may work for evacuation
2. The best position of obstacle should be 5 times of the diameter of granule
3. From dynamic analysis, the key to evacuation is the longer duration of system staying at disordered situation

Reference

[1]National Geography Emergency exit experiment: [National Geographic Channel]. (2014, December 15). *Crowd Control S1.E9 Time File*