Emergency Facilities Readiness Project

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Introduction

In Defense system test and evaluation, collecting sufficient data to evaluate system performance against operationally realistic threats is often not possible due to cost and resource restrictions, safety concerns, or lack of adequate or representative threats. Thus, a simulation technique frequently are used to augment live testing in order to facilitate a more complete evaluation of performance. In this project we will explore how many victims each hospital might expect in a disaster, and how long it would take to transport victims to the hospitals. We will focus on five hospitals in the Boston area and test how victims will be distributed to the hospitals in the event of a disaster. The dependent variables in this analysis include the first-aid facility, capabilities of the five hospitals and the proximity of the hospitals to the university campus. It is estimated that the transit time to each hospital is exponentially distributed with a certain average value depending on the overall capacity of the hospital. We can assume that each hospital has two ambulances, when one ambulance returned to the hospital, another ambulance arrived on campus. Below we will explore the number of victims in different hospitals step by step through simulation models.

Analysis

Problem 1

a. Average number of victims that can be expected at each hospital.

Triangle Distribution functions provide information for us about the triangle distribution on the interval from 20 to 85 with a maximum at 350. After performing 5,000 simulations, based on the different capabilities of these five hospitals, I derived the expected damage for each hospital The average number of people. In order to observe this result more intuitively I will list the average number of victims expected in each hospital in the table below:

	Allocation of Disaster Victims	Average Number of victims	Theoretical average
Beth Israel Medical	20%	30.41764	30.3

Tufts Medical	30%	45.62646	45
Massachusetts General	15%	22.81323	22.5
Boston Medical	20%	30.41764	30
Brigham and Women's	15%	22.81323	22.5

b. For each hospital, the average total time (in hours) needed to transport all victims hospital in the table below:

	Allocation of Disaster Victims	The average total time (in hours)
Beth Israel Medical	15	456.2646
Tufts Medical	8	365.0117
Massachusetts General	25	570.3307
Boston Medical	10	304.1764
Brigham and Women's	12	273.7588

c. For part (a) above, create a chart the displays the Law of Large Numbers in action for the Beth Israel Medical

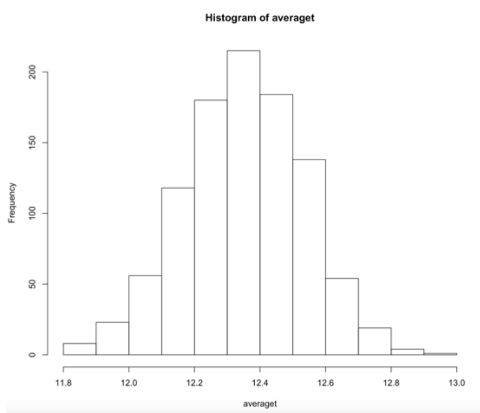
Let's take Beth Israel Medical as an example. The minimum and maximum are 20 and 350 victims respectively, and the peak is 85 victims. The theoretical average is equal to (450/3) * 20% = 30.3.

1	100	29.24751	21	2100	30.20667	41	4100	30.39259	61	6100	30.32383	81	8100	30.12041
2	200	29.15236	22	2200	30.65420	42	4200	30.19025	62	6200	30.08198	82	8200	30.25043
3	300	30.07902	23	2300	30.33184	43	4300	29.98659	63	6300	30.50607	83	8300	30.53637
4	400	30.48424	24	2400	30.37423	44	4400	30.53494	64	6400	30.62205	84	8400	30.39745
5	500	28.96350	25	2500	30.46338	45	4500	30.54552	65	6500	30.56708	85	8500	30.51490
6	600	30.22847	26	2600	30.22900	46	4600	30.23433	66	6600	30.05452	86	8600	30.16175
7	700	31.20931	27	2700	30.64139	47	4700	30.18859	67	6700	30.03028	87	8700	30.19387
8	800	29.69038	28	2800	30.07245	48	4800	30.06083	68	6800	30.28479	88	8800	30.51178
9	900	30.40499	29	2900	30.50124	49	4900	30.44160	69	6900	30.33399	89	8900	30.27541
10	1000	30.87250	30	3000	30.24159	50	5000	30.53845	70	7000	30.34203	90	9000	30.20094
11	1100	30.97345	31	3100	30.47376	51	5100	30.05334	71	7100	30.22358	91	9100	30.23997
12	1200	29.73739	32	3200	30.84950	52	5200	30.71375	72	7200	30.42057	92	9200	30.51936
13	1300	29.78830	33	3300	30.11516	53	5300	30.40018	73	7300	29.96686	93	9300	30.53672
14	1400	30.33040	34	3400	30.41576	54	5400	30.03890	74	7400	30.67791	94	9400	30.25100
15	1500	30.81243	35	3500	29.90104	55	5500	30.12537	75	7500	30.63715	95	9500	30.06026
16	1600	30.70048	36	3600	30.72550	56	5600	30.21010	76	7600	30.33559	96	9600	30.39152
17	1700	30.12086	37	3700	30.62558	57	5700	30.16653	77	7700	30.51623	97	9700	30.30508
18	1800	29.92337	38	3800	30.76414	58	5800	30.00649	78	7800	30.51535	98	9800	30.11158
19	1900	30.06752	39	3900	30.26540	59	5900	30.05170	79	7900	30.13670	99	9900	30.14701
20	2000	30.10780	40	4000	30.53237	60	6000	30.61495	80	8000	30.54703	100	10000	30.55069

By observing the chart above, I found that as the number of simulations increases, the average number of victims observed will approach 30.3, which is in line with the law of large numbers.

d. perform an exploratory data analysis of the total transport time.

After testing, we found that the 95% confidence interval for the total transit time of Beth Israel Medical Hospital was [311.3581 331.1317].



By looking at the histogram of the average transit time of each victim, we find that it appears as a bell curve. So we can draw a preliminary conclusion that this is a normal distribution. Below we will further verify this conclusion through the Chi-squared Goodness of fit test. We find that because p-value (0.64)> 0.05, we do not reject the null hypothesis. This is a normal distribution

2.

In the second question, we assume that the total number of victims is normally distributed with a mean of 175 victims and a standard deviation of 63 victims. Under this premise we will perform a simulation analysis consisting of 5,000 simulations.

a.

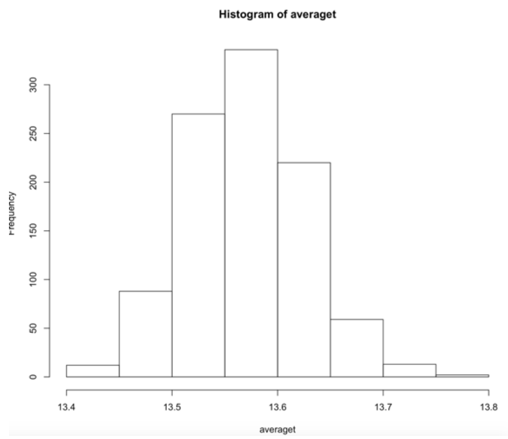
	Average in Minutes	Average Number of victims	average total time
Beth Israel Medical	15	22.49460	67.48380
Tufts Medical	8	11.99712	23.99424
Massachusetts General	25	37.49100	224.94600
Boston Medical	10	14.99640	52.48740
Brigham and Women’s	12	17.99568	44.98920

Through simulation technology we obtained the average numbers of victims expected at each hospital and the average total time needed to transport all victims. We can conclude that the higher the total average transit time of the hospital, the greater the average number of victims.

1	100	26.39206	21	2100	26.37375	41	4100	26.40456	61	6100	26.44236	81	8100	26.12479
2	200	26.14522	22	2200	25.95969	42	4200	26.44385	62	6200	26.20931	82	8200	26.15620
3	300	26.07853	23	2300	26.13286	43	4300	26.12489	63	6300	26.17498	83	8300	26.28714
4	400	25.58594	24	2400	26.20032	44	4400	26.31532	64	6400	26.09597	84	8400	26.21183
5	500	25.63080	25	2500	26.28948	45	4500	25.98561	65	6500	26.11760	85	8500	26.13033
6	600	26.08242	26	2600	26.31580	46	4600	26.12622	66	6600	26.27923	86	8600	26.22306
7	700	26.26045	27	2700	25.99843	47	4700	26.33024	67	6700	26.29604	87	8700	26.14613
8	800	26.60003	28	2800	26.30820	48	4800	26.41575	68	6800	26.20238	88	8800	26.25382
9	900	26.69400	29	2900	26.41919	49	4900	26.23506	69	6900	26.31377	89	8900	26.31945
10	1000	25.73421	30	3000	26.46659	50	5000	26.17960	70	7000	26.27328	90	9000	26.31886
11	1100	26.11143	31	3100	26.37410	51	5100	26.35595	71	7100	26.31710	91	9100	26.44916
12	1200	26.22482	32	3200	26.33797	52	5200	26.17799	72	7200	26.10356	92	9200	26.12960
13	1300	26.09531	33	3300	26.09084	53	5300	26.32361	73	7300	26.32006	93	9300	26.28215
14	1400	25.90687	34	3400	26.27755	54	5400	26.36054	74	7400	26.31327	94	9400	26.26882
15	1500	26.26828	35	3500	25.95959	55	5500	26.06885	75	7500	26.24158	95	9500	26.23836
16	1600	26.37965	36	3600	26.02505	56	5600	26.27136	76	7600	26.16033	96	9600	26.18927
17	1700	26.06305	37	3700	26.07295	57	5700	26.19869	77	7700	26.30064	97	9700	26.33321
18	1800	26.63528	38	3800	26.12252	58	5800	25.97767	78	7800	26.39450	98	9800	26.35804
19	1900	26.12786	39	3900	26.00246	59	5900	26.29008	79	7900	26.11954	99	9900	26.38638
20	2000	26.21165	40	4000	26.15074	60	6000	26.26397	80	8000	26.32034	100	10000	26.23571

I will use Beth Israel Medical as a sample to verify the law of large numbers. As the number of simulations increases, the average number of victims I observe will approach the theoretical average of 26.25 (175 * 0.15).

under the significance level of 0.05., the confidence interval for the total transport time of Beth Israel Medical hospital is [311.7103, 319.4832].



Finally we verified again that this is a normal distribution by observing the histogram and the Chi-squared Goodness of fit test. Because the P value = 0.98 is greater than 0.05, we do not reject the null hypothesis.

Conclusion:

In this project, we analyzed digital prototypes of physical models through simulation modeling to predict their performance in the real world. By analyzing this case and performing the modeling process, we understand the power of simulation technology and master important methods. Simulation modeling is used to help designers and engineers understand whether, under what conditions, and in which ways a part could fail and what loads it can with stand. In this case, we can conclude that Tufts Medical has the best first aid measures and capabilities in in the Boston area, Massachusetts General's performance is relatively weak. Authorities can use this information to take steps to improve first aid efficiency and reduce the number of victims in the Boston area. But there are still many limitations here such as the difficulty in finding the optimal values increases due to an increase in the number of parameters. Also in this project, it does not yield an answer but merely provides a set of the system's responses to different operating conditions .Simulation techniques are often difficult to find accurate answers but will provide valuable reference information for decision makers. I believe that as technology advances, designers will be able to improve the accuracy of simulation through machine learning in the future.

REFERENCES :

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