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CSCI 363 – Artificial Intelligence
Programming Assignment #2

Expectation Maximization

For Starting Parameters: P(gender=0): 0.7, P(weight=0|gender=0): 0.8,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.3

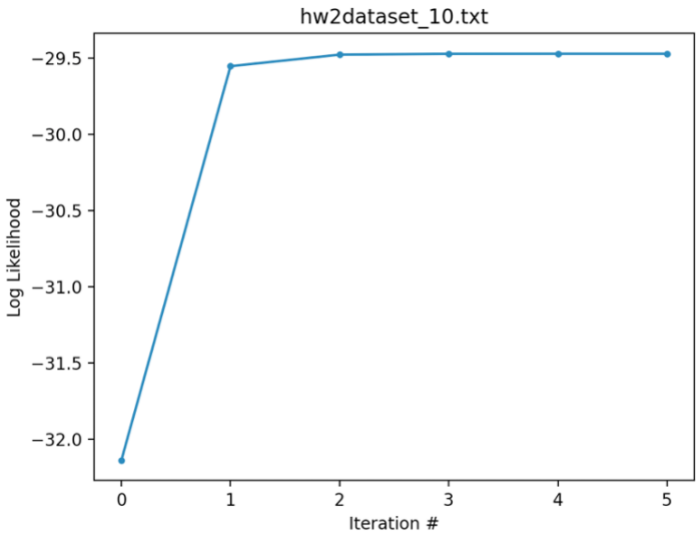
Dataset – 10% missing
Total number of iterations: 5
Final Probability Tables for dataset with 10% missing:

P(gender)	
gender = 0	0.7264774054539278
gender = 1	0.2735225945460722

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8623494698537574	0.13765053014624262
gender = 1	0.634399490228746	0.365600509771254

P(height | gender)		
	height = 0	height = 1
gender = 0	0.6882524820207717	0.3117475179792283
gender = 1	4.4809579222927327e-07	0.9999995519042078

Plot of log likelihood vs number of iterations:



***For Starting Parameters**:* P(gender=0): 0.7, P(weight=0|gender=0): 0.8,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.3

Dataset – 30% missing

Total number of iterations: 4

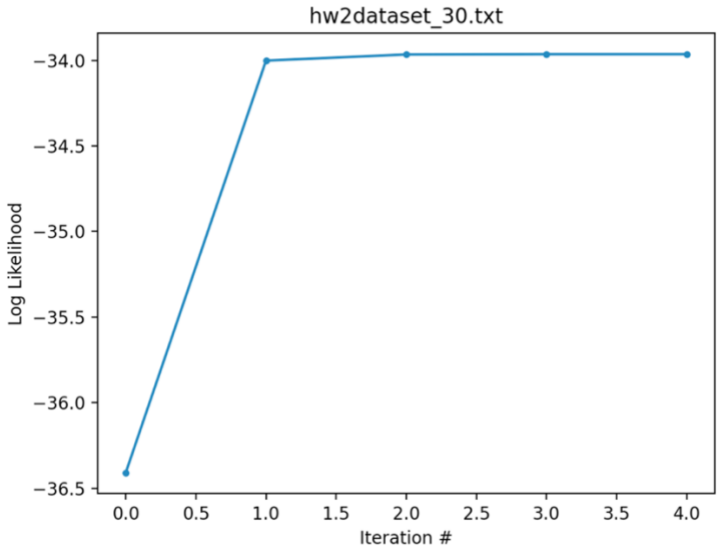
Final Probability Tables for dataset with 30% missing:

P(gender)	
gender = 0	0.5555458387152772
gender = 1	0.4444541612847228

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.892361626503551	0.107638373496449
gender = 1	0.23456234826423542	0.7654376517357646

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5323553298809207	0.4676446701190793
gender = 1	0.23456234826423542	0.7654376517357646

Plot of log likelihood vs number of iterations:



***For Starting Parameters**:* P(gender=0): 0.7, P(weight=0|gender=0): 0.8,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.3

Dataset – 50% missing

Total number of iterations: 30

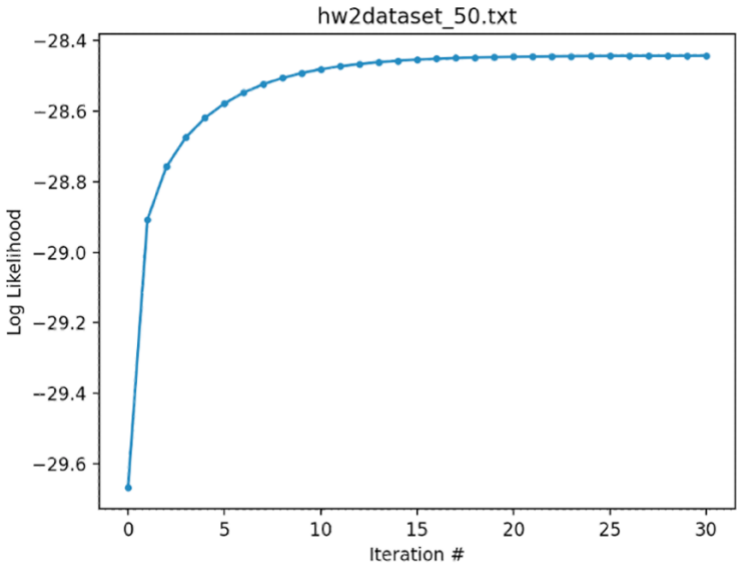
Final Probability Tables for dataset with 50% missing:

P(gender)	
gender = 0	0.7042255826974658
gender = 1	0.2957744173025342

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.6952799524485033	0.30472004755149673
gender = 1	0.3731427192237453	0.6268572807762547

P(height | gender)		
	height = 0	height = 1
gender = 0	0.8519068875091724	0.14809311249082757
gender = 1	0.00022103243568135175	0.9997789675643186

Plot of log likelihood vs number of iterations:



***For Starting Parameters**:* P(gender=0): 0.7, P(weight=0|gender=0): 0.8,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.3

Dataset – 70% missing

Total number of iterations: 65

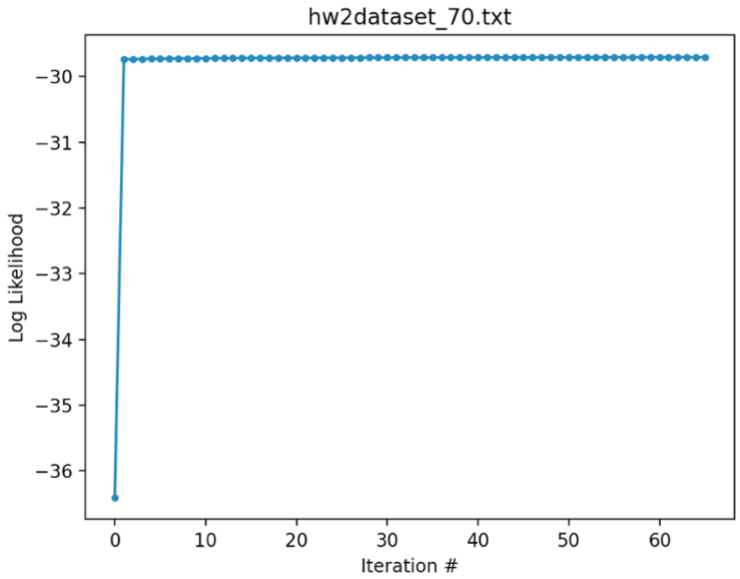
Final Probability Tables for dataset with 70% missing:

P(gender)	
gender = 0	0.5734363663211598
gender = 1	0.4265636336788402

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.5026346064029699	0.49736539359703014
gender = 1	0.02759503339629995	0.9724049666037

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5465778472530174	0.4534221527469826
gender = 1	0.2029530380097244	0.7970469619902756

Plot of log likelihood vs number of iterations:



For Starting Parameters: P(gender=0): 0.7, P(weight=0|gender=0): 0.8,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.3

Dataset – 100% missing

Total number of iterations: 8

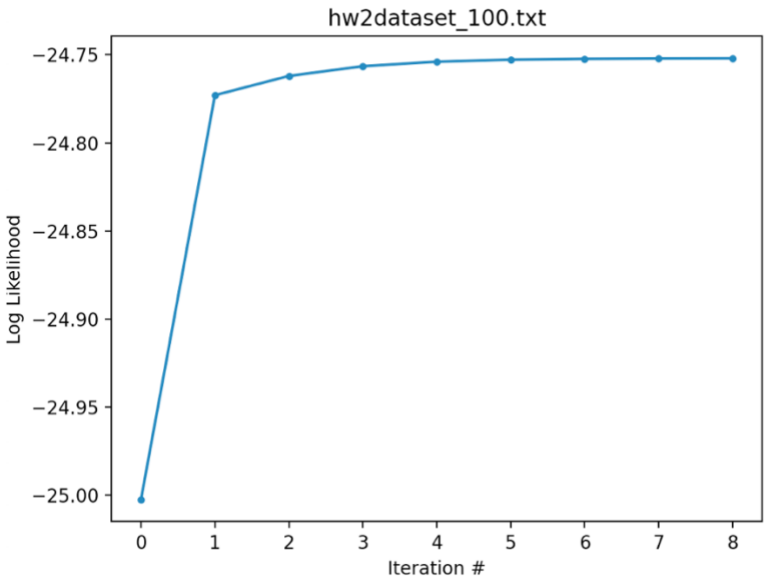
Final Probability Tables for dataset with 100% missing:

P(gender)	
gender = 0	0.7208064745394387
gender = 1	0.2791935254605613

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8312207628336056	0.16877923716639442
gender = 1	0.3612214581679902	0.6387785418320098

P(height | gender)		
	height = 0	height = 1
gender = 0	0.7812997789420087	0.21870022105799125
gender = 1	0.31101745872912084	0.6889825412708792

Plot of log likelihood vs number of iterations:



Testing my EM algorithm with different starting parameters:

For Starting Parameters: P(gender=0): 0.2, P(weight=0|gender=0): 0.5,
P(weight=0|gender=1): 0.4, P(height=0|gender=0): 0.9
P(height=0|gender=1): 0.5

Dataset – 10% missing
Total number of iterations: 6
Final Probability Tables for dataset with 10% missing:

P(gender)	
gender = 0	0.7264746845785033
gender = 1	0.2735253154214967

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8623489543093722	0.1376510456906278
gender = 1	0.6344031270162248	0.3655968729837752

P(height | gender)		
	height = 0	height = 1
gender = 0	0.6882551197414375	0.3117448802585625
gender = 1	2.8873488029524936e-07	0.9999997112651197

Dataset – 30% missing
Total number of iterations: 4
Final Probability Tables for dataset with 30% missing:

P(gender)	
gender = 0	0.5554358886158085
gender = 1	0.4445641113841915

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8925379181266212	0.1074620818733788
gender = 1	0.23450477816897297	0.765495221831027

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5324603572430127	0.46753964275698734
gender = 1	0.23450477816897297	0.765495221831027

Dataset – 50% missing

Total number of iterations: 34

Final Probability Tables for dataset with 50% missing:

P(gender)	
gender = 0	0.7042142738594785
gender = 1	0.29578572614052145

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.6952863841757	0.3047136158243
gender = 1	0.37313972274271556	0.6268602772572844

P(height | gender)		
	height = 0	height = 1
gender = 0	0.8519040969047421	0.14809590309525789
gender = 1	0.0002602390633130117	0.999739760936687

Dataset – 70% missing

Total number of iterations: 82

Final Probability Tables for dataset with 70% missing:

P(gender)	
gender = 0	0.5735005683393242
gender = 1	0.42649943166067583

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.5026814135172325	0.4973185864827675
gender = 1	0.027460584434190582	0.9725394155658094

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5465223133948941	0.4534776866051059
gender = 1	0.20297598597219402	0.797024014027806

Dataset – 100% missing

Total number of iterations: 25

Final Probability Tables for dataset with 100% missing:

P(gender)	
gender = 0	0.3292449422808746
gender = 1	0.6707550577191255

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.9714576680626356	0.02854233193736444
gender = 1	0.566753052065082	0.433246947934918

P(height | gender)		
	height = 0	height = 1
gender = 0	0.9798677696598495	0.020132230340150548
gender = 1	0.4880820337735618	0.5119179662264381

Testing my EM algorithm with different starting parameters:

For Starting Parameters: P(gender=0): 0.3, P(weight=0|gender=0): 0.4,
P(weight=0|gender=1): 0.5, P(height=0|gender=0): 0.7
P(height=0|gender=1): 0.8

Dataset – 10% missing

Total number of iterations: 6
Final Probability Tables for dataset with 10% missing:

P(gender)	
gender = 0	0.7264750490978711
gender = 1	0.2735249509021289

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8623490233777761	0.13765097662222392
gender = 1	0.6344026397950752	0.36559736020492484

P(height | gender)		
	height = 0	height = 1
gender = 0	0.6882547539628485	0.3117452460371515
gender = 1	3.4301439796083014e-07	0.999999656985602

Dataset – 30% missing

Total number of iterations: 5
Final Probability Tables for dataset with 30% missing:

P(gender)	
gender = 0	0.5555081407853463
gender = 1	0.44449185921465373

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.8924277940353176	0.10757220596468242
gender = 1	0.23453544353875086	0.7654645564612491

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5323970666417437	0.4676029333582563
gender = 1	0.23453544353875086	0.7654645564612491

Dataset – 50% missing

Total number of iterations: 34

Final Probability Tables for dataset with 50% missing:

P(gender)	
gender = 0	0.7042093523952708
gender = 1	0.2957906476047292

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.6952891834470403	0.30471081655295973
gender = 1	0.3731384183073085	0.6268615816926915

P(height | gender)		
	height = 0	height = 1
gender = 0	0.8519028821161874	0.14809711788381263
gender = 1	0.0002773011315914062	0.9997226988684086

Dataset – 70% missing

Total number of iterations: 79

Final Probability Tables for dataset with 70% missing:

P(gender)	
gender = 0	0.5734762475244354
gender = 1	0.4265237524755646

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.5026636828025575	0.49733631719744253
gender = 1	0.027511521577566794	0.9724884784224332

P(height | gender)		
	height = 0	height = 1
gender = 0	0.5465433488935303	0.4534566511064697
gender = 1	0.20296729235978372	0.7970327076402163

Dataset – 100% missing

Total number of iterations: 17

Final Probability Tables for dataset with 100% missing:

P(gender)	
gender = 0	0.31286283094945866
gender = 1	0.6871371690505413

P(weight | gender)		
	weight = 0	weight = 1
gender = 0	0.39334969440677164	0.6066503055932284
gender = 1	0.8396220245980573	0.16037797540194265

P(height | gender)		
	height = 0	height = 1
gender = 0	0.3317800026007599	0.6682199973992401
gender = 1	0.7948898614939178	0.20511013850608217

Evaluation and Analysis Questions

- Do multiple starting points help in finding better solutions?

Answer: Yes, different starting points affects the number of iterations that is needed before convergence of the EM algorithm. The better fit the starting points are with the dataset with missing data, the less iterations the EM algorithm should take to converge. From the extra tests of starting points I tested, I did not find a better solution than the one given to try to test in the Assignment 2 doc.

- Do some of the different solutions have the same log likelihood scores?

Answer: No, the log likelihood scores for some of the different solutions are similar, but they are not exactly the same. Due to the fact that different starting points has an effect on the solution, the final probability tables will always have similar results, but there will be slight differences in the probabilities. Therefore, leading to similar log likelihoods but not the same log likelihoods.

- How does the data missing rate affect your algorithm and the results?

Answer: The data missing rate affects the number of calculations needed to be done in the E-step of the EM algorithm. The higher the rate of missing data, the more calculations has to be done in the E-step. The results for the final probability tables for the datasets with 10%, 30%, 50%, and 70% missing data will have a similar result no matter what the initial starting points are. The final probability tables will have slightly different probabilities due to the initial starting points used. However, the results for the final probability tables for the dataset with 100% missing data will have different results each time depending on the initial starting points because there is no row of complete data given in the dataset. Therefore, the dataset with 100% missing data will depend solely on the initial starting points. The data missing rate also affects the number of iterations needed in the EM algorithm. The higher the rate of missing data (not including 100% missing data), the higher the chances of the iterations needed will increase.