CSC384H, Summer 2020

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Question 3: IS YOUR BAYES NETWORK FAIR?

(1) Separation holds but not sufficiency We set the protected attribute A = Gender, C = Prediction, Y = Hyperlipidemia

	Hyperlipidemia=YES		Hyperlipidemia=NO	
	Prediction=YES	Prediction=NO	Prediction=YES	Prediction=NO
Gender=Female	0	0.1738498299096415775	0	0.3011501700903584225
Gender=Male	0	0.2312171312855648475	0	0.2937828687144351

From the table, we can calculate the values:

- $P($ Prediction = YES | Hyperlipidemia = YES, Gender = Female $) = 0$
- $P($ Prediction = YES | Hyperlipidemia = YES $) = 0$
- $P($ Prediction = YES | Hyperlipidemia = NO, Gender = Female $) = 0$
- $P($ Prediction = YES | Hyperlipidemia = NO $) = 0$
- $P($ Prediction = NO | Hyperlipidemia = YES, Gender = Female $) = 1$
- $P($ Prediction = NO | Hyperlipidemia = YES $) = 1$
- $P($ Prediction = NO | Hyperlipidemia = NO, Gender = Female $) = 1$
- $P($ Prediction = NO | Hyperlipidemia = NO $) = 1$

However,

- $P($ Hyperlipidemia = NO | Prediction = NO, Gender = Female $) = \frac{0.3011}{0.1738+0.3011} = 0.634$
- $P($ Hyperlipidemia = NO | Prediction = NO $) = \frac{0.3011+0.2938}{1} = 0.5949$

Thus, Separation holds but not sufficiency.

(2) Sufficiency holds but not separation We set the protected attribute A = Gender, C = Hyperlipidemia, Y = Diabetes From the table, we can calculate the values similarly as example (1) and find $P($ Diabetes

	Diabetes=YES		Diabetes=NO	
	Gender=Female	Gender=Male	Gender=Female	Gender=Male
Hyperlipidemia=YES	0.10725	0.14275	0.10725	0.14275
Hyperlipidemia=NO	0.1265	0.1235	0.1265	0.1235

| Hyperlipidemia, Gender $) = P($ Diabetes | Hyperlipidemia $)$. However, $P($ Hyperlipidemia | Diabetes, Gender $) = P($ Hyperlipidemia | Diabetes $)$ does not holds. Thus, sufficiency holds but not separation.

I am not sure whether my second example is correct,but I found something from the procedure. Since separation means A is independent of C given Y, and sufficiency means A is independent of Y given C, from a Bayes Network perspective, thinking A, C and Y as nodes in the network, the two separation cannot be achieved simultaneously considering all 3 cases when d-separation's idea is applied. Also, I found some deeper dicussion on https://fairmlbook.org/classification.html.