Homework Problem: Weather and Transportation

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10/10 points (graded)

Update (October 18, 2016): *There was a bug with part (b) where not every possible solution was accepted. The problem has been updated and the number of attempts has been increased. Note that because of how the edX software platform is set up, now that we've modified the problem,* ***you will have to update your answers to that part and all the parts afterward for that problem****.*

What this problem is getting you to see (October 12, 2016): *This problem is intentionally getting you to think about there being a mismatch between a probability distribution that corresponds to the problem you're trying to solve, and trying to encode that probability distribution as a graphical model. Graphical models encode very specific structure. Some times they cannot exactly encode the probability distribution that you are working with.*

In this problem we'll develop a graphical model for how the weather affects a student's mode of transport to the MIT campus. Consider two independent binary random variables R and C that are 1 with probability $1/2$ if it is rainy and cold respectively, and 0 otherwise. The student walks if it's not cold and not raining and takes the Tech shuttle when it is warm and rainy or cold and not raining. However, if it is cold and rainy, he has to walk because the Tech shuttle is too crowded. We'll denote walking and taking the Tech shuttle by binary random variables W and T respectively.

- **(a)** Indicate whether the following conditional independence statements are True or False. Although we won't ask you to input justifications, you should be able to justify your answers.

Exercises due Oct 27, 2016 at 02:30 IST

Week 6: Special Case: Marginalization in Hidden Markov Models
Exercises due Oct 27, 2016 at 02:30 IST

Week 6: Homework 5
Homework due Oct 27, 2016 at 02:30 IST

Weeks 6 and 7: Mini-project on Robot Localization (to be posted)

$T \perp W \mid R$

- True
- False ✔

$T \perp W \mid (R, C)$

- True ✔
- False

$R \perp C \mid W$

- True
- False ✔

$R \perp T$

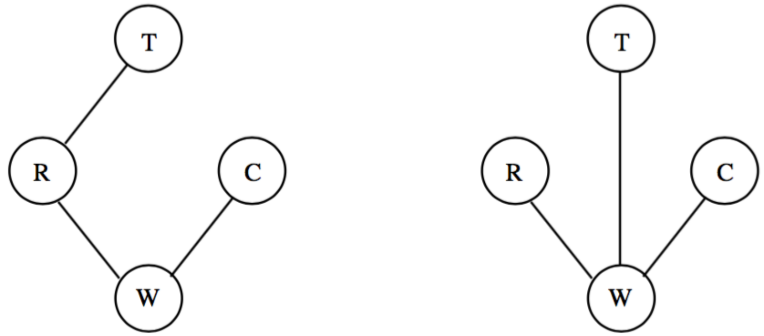
- True ✔
- False

- **(b)** Shown below are two possible graphical models for these random variables. Neither of them represent the conditional independencies between the above random variables perfectly.

  A missing independence statement refers to an independence statement that holds for the actual probability distribution, but that the graphical model doesn't imply *at least not from looking at the graph*. (For example, if your underlying distribution consists of 2 independent random variables and you encode it using a graphical model with 2 nodes connected by an edge, then note that in general, a graphical model with 2 nodes connected by an edge does *not* imply that the two random variables are independent. Thus, we say that there is a missing independency implied by the graphical model. However, of course it is possible to set the pairwise potential so that the graphical model with 2 nodes connected does represent 2 independent random variables, but we wouldn't be able to tell this from just looking at the graph.)

  An extra conditional independence statement is one where the graphical model necessarily implies a conditional independence statement, but this conditional independence does not actually hold in the underlying probability distribution. (For example, suppose we have a distribution with 2 random variables that are not independent, and we try to encode it with a graphical model with 2 nodes that are not connected by an edge. In this case, the graphical model actually has no hope of being able to represent the underlying distribution! It implies an independence statement that simply doesn't hold in the underlying distribution. More generally an extra conditional independence statement builds on this same idea but we do conditioning first.)

  For each graph, provide all the independencies that are missing, and among the conditional independencies listed, select all that are extra.



For the graphical model on the left:

- Select all the missing independencies below.

- [x] $R \perp C$
- [x] $R \perp T$
- [x] $R \perp W$
- [x] $C \perp T$
- [x] $C \perp W$
- [ ] $T \perp W$

- Of the conditional independencies listed below, select all that are extra:

- [x] $C \perp R \mid W$
- [ ] $R \perp T \mid W$
- [ ] $C \perp T \mid W$
- [ ] $C \perp R \mid T$
- [ ] $R \perp W \mid T$
- [ ] $C \perp W \mid T$
- [ ] $C \perp W \mid R$
- [x] $C \perp T \mid R$
- [x] $T \perp W \mid R$
- [ ] $R \perp W \mid C$
- [ ] $R \perp T \mid C$
- [ ] $T \perp W \mid C$

For the graphical model on the right:

- Select all the missing independencies below.

  - [x] $R \perp C$
  - [x] $R \perp T$
  - [x] $R \perp W$
  - [x] $C \perp T$
  - [x] $C \perp W$
  - [ ] $T \perp W$

- Of the conditional independencies listed below, select all that are extra:

  - [x] $C \perp R \mid W$
  - [ ] $R \perp T \mid W$

- [ ] $C \perp T \mid W$
- [ ] $C \perp R \mid T$
- [ ] $R \perp W \mid T$
- [ ] $C \perp W \mid T$
- [ ] $C \perp W \mid R$
- [ ] $C \perp T \mid R$
- [ ] $T \perp W \mid R$
- [ ] $R \perp W \mid C$
- [ ] $R \perp T \mid C$
- [ ] $T \perp W \mid C$

✔

- **(c)** In general, if you had two graphical models, one with missing independencies (and it doesn't imply extra independencies) and another with extra ones (and it doesn't have missing independencies), which model should you choose?

- (selected) The graphical model with missing independencies ✔
- The graphical model with extra independencies

Submit You have used 6 of 15 attempts

✔ Correct (10/10 points)

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