

CS151 - Written Problem 6  
To be done by: Wednesday, Oct. 27

1. More Taxi prediction
  - (a) Look at the Taxi cab example again from lecture notes and make sure that you understand how we calculated 1) the filtered probability of  $P(\text{CarOrTaxi}_2|\text{red}, \text{yellow})$  2)  $P(\text{CarOrTaxi}_3|\text{red}, \text{yellow})$
  - (b) Let's say you see a third vehicle now that is yellow. What is the probability that this third vehicle is a Taxi?
  - (c) Now that you've seen the color of the third car, how does this change your probability of the second part being a cab, that is, what is  $P(\text{CarOrTaxi}_2|\text{red}, \text{yellow}, \text{yellow})$ ?
  - (d) How did the smoothed estimate from (c) change from our filtered estimate when we only had seen a red and a yellow car? Explain qualitatively why this new estimate in (c) makes sense, given your evidence and transition models (I am looking for an English description here).
  
2. An appealing use of HMMs is for localization: in other words, given a map, and a set of observations of your environment, figure out where you are. Suppose we are walking around the Claremont Colleges campus, which is roughly a 1x1 mile square (5280 feet by 5280 feet) (OK, not quite, but close enough...). Weve been given a map, and wed like to figure out where we are every ten seconds, down to a resolution of 1 foot.
  - (a) Let's start to formalize this as an HMM. What does each of the hidden states  $X_t$  represent? What is the domain of each state variable? How big is this domain?
  - (b) Suppose that youre walking with a blindfold on, at roughly 2 miles per hour, trying to go straight. You can ignore obstacles

(such as buildings) for now. Whats a reasonable transition model,  $P(X_t|X_{t-1})$ ?

- (c) Assume that we get dropped off somewhere on the campus blindfolded but we dont know where. Whats a good starting, prior distribution  $P(X_1)$ ?
- (d) Suppose that every ten seconds we can stop and take our blindfold off, and look for Smith Tower (on Pomona's campus). If we can see it, we measure approximately how far away it is by measuring its apparent height. We then report the approximate distance in 100 foot increments. What should each evidence variable  $E_t$  represent? What is the domain of each evidence variable? How big is this domain?
- (e) Formalize the emission model  $P(E_t|X_t)$
- (f) Suppose we walk "straight" for 1 minute (60 seconds), stopping every 10 seconds to measure our distance to Smith Tower. 1) We want to know where we are. What HMM question is this? 2) We want to know where we walked for that 60 seconds. What HMM questions is this?