18.600: Lecture 23

Conditional probability, order statistics, expectations of sums

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Outline

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Conditional probability densities

Order statistics

Expectations of sums

Conditional distributions

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- This amounts to restricting $f(x, y)$ to the line corresponding to the given y value (and dividing by the constant that makes the integral along that line equal to 1).
- This definition assumes that $f_Y(y) = \int_{-\infty}^{\infty} f(x, y)dx < \infty$ and $f_Y(y) \neq 0$. This *usually* safe to assume. (It is true for a probability one set of y values, so places where definition doesn't make sense can be ignored).

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- Precisely, define $F_{X|Y=y}(a) := \lim_{\epsilon \to 0} P\{X \leq a | Y \in (y - \epsilon, y + \epsilon)\}$.
- Then set $f_{X|Y=y}(a) = F'_{X|Y=y}(a)$. Consistent with definition from previous slide.

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- Both $\{\theta = 0\}$ and $\{Y = 0\}$ describe the same probability zero event. But our interpretation of what it means to condition on this event is different in these two cases.
- Conditioning on (X, Y) belonging to a $\theta \in (-\epsilon, \epsilon)$ wedge is very different from conditioning on (X, Y) belonging to a $Y \in (-\epsilon, \epsilon)$ strip.

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- So if $X = \max\{X_1, \dots, X_n\}$, then what is the probability density function of X?
- Answer: $F_X(a) = \begin{cases} 0 & a < 0 \\ a^n & a \in [0, 1] \\ 1 & a > 1 \end{cases}$. And $f_x(a) = F_X'(a) = na^{n-1}$.

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- Yes.

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- Up to a constant, $f(x) = x^7(1 - x)^2$.
- General beta (a, b) expectation is $a/(a + b) = 8/11$. Mode is $\frac{(a-1)}{(a-1)+(b-1)} = 2/9$.

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- Choose Y uniformly on $[0,1]$ and note that $g(Y)$ has the same probability distribution as X.
- So $E[X] = E[g(Y)] = \int_0^1 g(y)dy$, which is indeed the area under the graph of $1 - F_X$.

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