STA286 Lecture 12

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a (strange) new way to completely characterize the distribution of a random variable (note: section 7.3 of book)

what is important about a random variable?

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We will use whichever one is most convenient for a given situation.

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Definition: For integers $k \geqslant 0$, $E\left(X^k\right)$ (if it exists) is called the kth *moment* of a random variable.

Note: calculating all these moments is not the point at all. The concept itself is what is important.

the complete moment sequence *characterizes* a distribution

If turns out that if *all* moments exist:

$$\left\{ E(X), E\left(X^2\right), E\left(X^3\right), E\left(X^4\right), \ldots \right\}$$

then this sequence *usually* gives a *characterization* of the distribution of X.

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&= E\left(e^{tX}\right)
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&= \left.\int_{-\infty}^{\infty} x^r e^{tx} f(x)\, dx\right|_{t=0} = \int_{-\infty}^{\infty} x^r f(x)\, dx = E(X^r)
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mgf example

Reconsider the generic "observe until the first defective item" example, in which a defective item is produced with probability p. The pmf of the number of items X is:

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Tedious calculus shows $M'_X(t) = \frac{pe^t}{(1-(1-p)e^t)^2}$, which when evaluated at 0 is $\frac{1}{p}$. (I hope!)

the more important use of of mgfs

Recall that if X and Y are independent, $E(XY) = E(X)E(Y)$. This can extend easily to:

$$E(g(X)h(Y)) = E(g(X))E(h(Y))$$

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distributions with names, because they are used all the time to model actual things

a few conventions

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Finally, a collection of random variables is often called a "process". We will examine two processes that are central to probability modeling.

the Bernoulli distributions

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There is usually more than one at a time. A *Bernoulli process* is a sequence of independent Bernoulli(p) random variables with the same p:

$$X_1, X_2, X_3, X_4 \ldots$$

Often each X_i is called a (Bernoulli) *trial*, or an *experiment*.

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Is this actually a valid pmf? Yes, if you recall the *Binomial theorem*:

$$(a + b)^n = \sum_{k=0} \binom{n}{k} a^k b^{n-k}$$

Let $a = p$ and $b = 1 - p$.