18.600: Lecture 10

Variance and standard deviation

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Outline

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- Also,

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- Variance is one way to measure the amount a random variable "varies" from its mean over successive trials.

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- Seven words to remember: "expectation of square minus square of expectation."

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- Seven words to remember: "expectation of square minus square of expectation."
- Original formula gives intuitive idea of what variance is (expected square of difference from mean). But we will often use this alternative formula when we have to actually compute the variance.

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- $E[X] = .4 \cdot 5 + .5 \cdot 6 + .1 \cdot 7 = 5.7$
- Variance?
- $.4 \cdot 25 + .5 \cdot 36 + .1 \cdot 49 - (5.7)^2 = 32.9 - 32.49 = .41,$

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- Yes.
- We showed earlier that $E[aX] = aE[X]$. We claim that $\mathrm{Var}[aX] = a^2\mathrm{Var}[X]$.
- Proof: $\mathrm{Var}[aX] = E[a^2X^2] - E[aX]^2 = a^2E[X^2] - a^2E[X]^2 = a^2\mathrm{Var}[X]$.

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- If we switch from feet to inches in our "height of randomly chosen person" example, then X, $E[X]$, and $\mathrm{SD}[X]$ each get multiplied by 12, but $\mathrm{Var}[X]$ gets multiplied by 144.

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- So $E[A] = \sum_{k=0}^{4} kP\{A = k\}$,
- and $\mathrm{Var}[A] = \sum_{k=0}^{4} k^2 P\{A = k\} - E[A]^2$.

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- $E[A_i A_j] = (1/13)(3/51) = (1/13)(1/17)$. So $E[A^2] = \frac{5}{13} + \frac{20}{13\times 17} = \frac{105}{13\times 17}$.

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- $\mathrm{Var}[A] = E[A^2] - E[A]^2 = \frac{105}{13 \times 17} - \frac{25}{13 \times 13}$.

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$$E[\sum_{i=1}^n X_i \sum_{j=1}^n X_j] = \sum_{i=1}^n \sum_{j=1}^n E[X_i X_j] = n \cdot \frac{1}{n} + n(n-1)\frac{1}{n(n-1)} = 2.$$

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- So $\mathrm{Var}[X] = E[X^2] - (E[X])^2 = 2 - 1 = 1$.