Biosignals and Systems

Basic Signal Statistics

Basic Signal Statistics

- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value
- Likelihood Ratio
- Relative Risk
- Absolute Risk
- Number needed to treat/harm

[4] Christopher M.Bishop, " **Pattern Recognition and Machine Learning**", Springer, 2006

[18] Kirkwood BR. Essentials of medical statistics. Oxford, Blackwell Science, 1988.

Basic Signal Statistics - Sensitivity and Specificity

➢ Four possible situations:

Condition is:

	Present	Absent	
Present	True Positive	False Positive	This is Total # of "positive" tests
Absent	False Negative	True Negative	This is Total # of "negative" tests

Test Result:

[4] Christopher M.Bishop, " **Pattern Recognition and Machine Learning**", Springer, 2006

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Basic Signal Statistics - Sensitivity and Specificity

- ➤ *Sensitivity* is the proportion of condition present cases on which the test returned "positive"
- ➤ Analogous to the hit rate (H) in Signal Detection Theory

$$S\text{ensivity} = \frac{\#\,\text{True Positives}}{\#\,\text{True Postives} + \#\text{False Negatives}}$$

- ➤ *Specificity* is the proportion of condition absent cases on which the test returned "negative"
- ➤ Analogous to the Correct Rejection rate in Signal Detection Theory

$$Specificity = \frac{\#\,\text{True Negative}}{\#\,\text{True Negative} + \#\text{False Positive}}$$

Sensitivity and Specificity have a similar relationship: as a cut-off value for a test becomes more stringent the sensitivity goes down and the specificity goes up…and vice versa

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➢ **Likelihood Ratio** is the ratio of True Positive *rate* to False Positive *rate*

$$\text{Likelihood Ratio} = \frac{\text{Sensitivity}}{1 - \text{Specificity}}$$

➢ If a test is positive, how likely is it that the condition is present?

Positive Predictive Value is the proportion of "positive" test results that are correct

$$PPV = \frac{\#\,\text{True Positives}}{\#\,\text{True Postives} + \#\text{False Positives}}$$

➢ **Negative Predictive Value** is the proportion of "negative" test results that are correct

$$NPV = \frac{\#\,\text{True Negatives}}{\#\,\text{True Negatives} + \#\text{False Negatives}}$$

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➤ **Relative Risk** is the ratio of Exposure Events to Non-Exposure Events

$$\text{Exposure Event Rate} = \frac{A}{A+B} \qquad\qquad \text{Control Event Rate} = \frac{C}{C+D}$$

$$\text{Relative Risk} = \frac{\text{Exposure Event Rate}}{\text{Control Event Rate}} = \frac{A/(A+B)}{C/(C+D)}$$

➤ **Relative Risk Reduction** is the difference between event rates in the exposure and non-exposure groups, expressed as a fraction of the non-exposure event rate(it can be positive or negative)

$$\text{Relative Risk Reduction} = \frac{\text{Exposure Event Rate - Control Event Rate}}{\text{Control Event Rate}}$$

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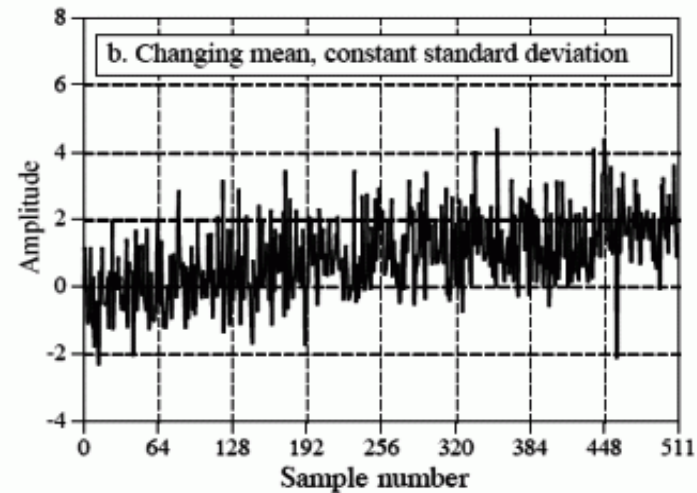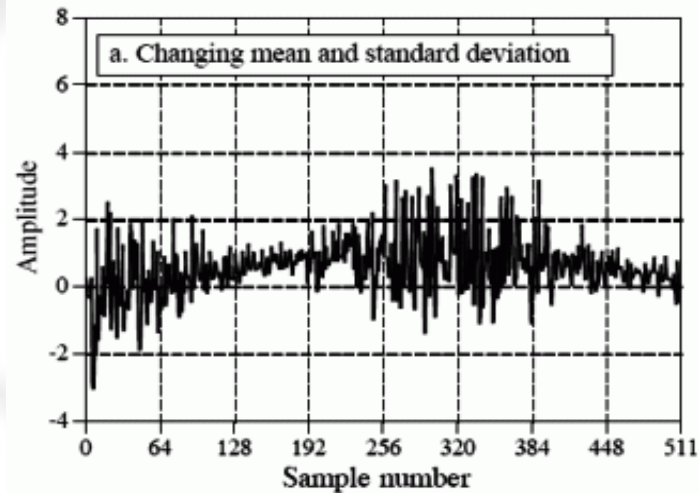[18] Kirkwood BR. Essentials of medical statistics. Oxford, Blackwell Science, 1988.

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➢ The **absolute risk reduction** conveys effect size

$$\text{Absolute Risk Reduction} = \left|\text{Exposure Rate } - \text{ Control Rate}\right|$$

➢ An intuitive version is to consider the reciprocal - the "**number needed to treat or harm**"

$$\text{Number Needed to Treat or Harm} = \frac{1}{\text{Absolute Risk Reduction}}$$

➢ Indicates the number of individuals that would have to be exposed to the treatment in order to cause one to have the outcome of interest

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Mean:

$$\mu = \frac{1}{N} \sum_{i=0}^{N-1} X_i$$

Standard deviation:

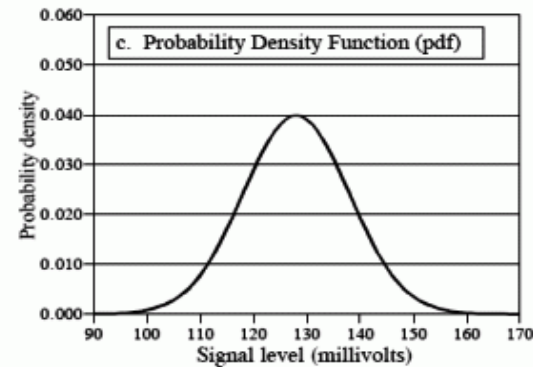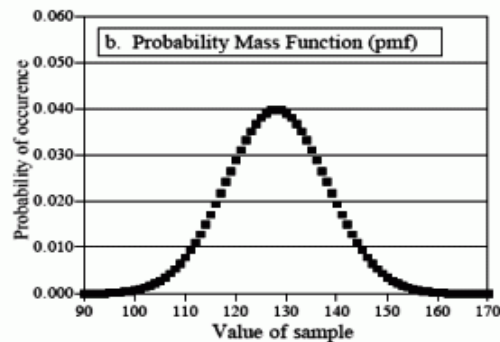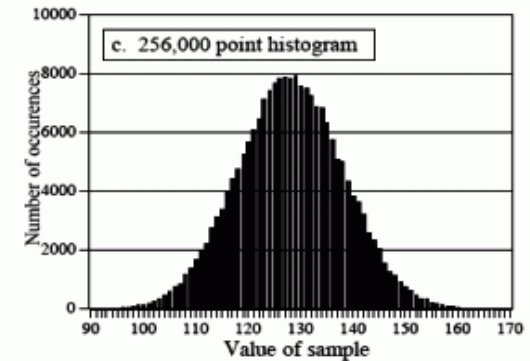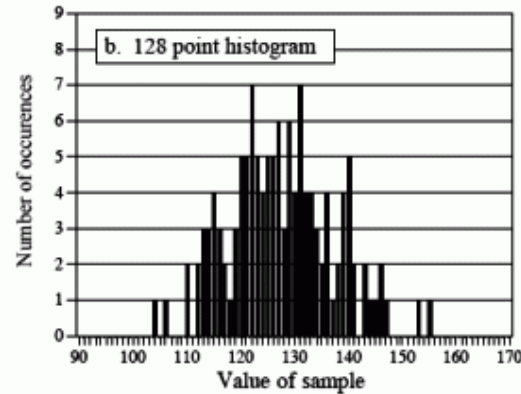$$\sigma^2 = \frac{1}{N-1} \sum_{i=0}^{N-1} (X_i - \mu^2)$$
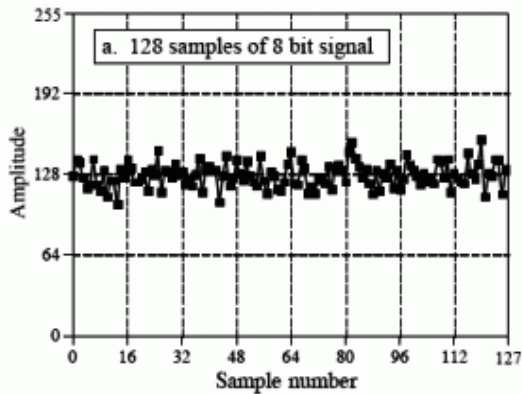
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Histogram, Probability mass function, Probability density function

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