Contents for Statistics at the Bachelor in Biomedical Engineering (2022–2023)

Coordinating teacher: Ignacio Cascos

BLOCK 0: DESCRIPTIVE STATISTICS

0. Descriptive Statistics

0.1 Main definitions

- Population, sample, and variable
- Types of variables

0.2 Frecuencies and their tables

0.3 Grouped data

0.4 Measuring the location of the data

- Measuring central location: sample mean, median, mode,...
- Quantiles (quartiles and percentiles)

0.5 Measuring the spread of the data

- sample range, interquartile range, sample variance, standard deviation,...

0.6 Charts

- Bar chart, pie chart, box plot, histogram, frequency polygon,...

0.7 Measuring the shape of the distribution of the data

0.8 Simulateneous description of two variables

- Marginal and conditional distributions and statistical independence
- Simple linear regression (ordinary least squares) and correlation

BLOCK I: PROBABILITY

1. Introduction to Probability

1.1 Introduction

1.2 Random phenomena

- Events, operations with events and their properties

1.3 Definition of probability and properties

- Definition of probability
- Interpretations of the probability
- Elementary properties

1.4 Conditional probability

- Independence between events
- Definition of conditional probability

1.5 Bayes Theorem

- Multiplication rule for probabilities
- Total probability rule
- Bayes Theorem

2. Random variables

2.1 Definition of random variable

2.2 Discrete random variables

- Probability (mass) function
- Distribution function of a discrete random variable

2.3 Continuous random variables

- Density (mass) function
- Distribution function of a continuous random variable

2.4 Characteristic features of a random variable

- Central location parameters
- Non-central location parameters
- Scatter parameters
- Shape parameters

2.5 Transformations of random variables

2.6 Random vectors

- Joint distribution
- Independence of random variables
- Mean vector and covariance matrix

3. Probability models

Discrete probability models

3.1 Binomial distribution

3.2 Poisson distribution

Continuous probability models

3.3 Normal distribution

- Central Limit Theorem (sample mean)

3.4 Models related with the Normal distribution

3.5 Multivariate normal distribution

BLOCK II: STATISTICAL INFERENCE

4. Parameter Estimation

4.1 Introduction and basic concepts

- Sample, statistic, estimator, bias, variance, mean square error, consistency

4.2 Sampling distributions

- Distribution of the sample mean
- Distribution of the sample variance
- Sampling distributions for normal populations

4.3 Maximum Likelihood Estimation

4.4 Properties of Maximum Likelihood Estimators (MLEs)

4.5 Inference for MLEs

- Introduction to Confidence Intervals and Hypothesis testing

5. Statistical Inference

5.1 Introduction

5.2 Confidence Interval on the mean of a normal population with unknown variance

- Sampling size

5.3 Hypothesis testing

- Generalities
- Critical region, power, and p-value
- Confidence Intervals and hypothesis tests

5.4 Particular tests for a single sample

- Inference for the mean (proportion) in big samples
- Inference for the mean of a normal population with unknown variance
- Inference for the variance of normal populations
- Inference based on the Maximum Likelihood Estimator

5.5 Particular tests two samples

- Inference for the mean difference: independent samples
- Inference for the mean difference: paired data
- Comparison of two variances

BLOCK III: APPLICATIONS

6. Statistical quality control

6.1 Introduction to statistical process control

6.2 Variables charts, $\overline{X}$-chart

6.3 Attributes charts, p and np charts

7. Linear Regression

7.1 Introduction

7.2 Simple linear regression

- Least squares estimators
- Inference in simple linear regression
- Adequacy of the regression model

7.3 Multiple linear regression

- Least squares estimators
- Inference in multiple linear regression
- Multicollinearity
- Dummy variables

7.4 Comparison of three or more population means (ANOVA)