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January 22, 2022

## 1 Bayes' Theorem - Lab

### 1.1 Introduction

In this lab, you'll practice Bayes' Theorem in some simple word problems.

### 1.2 Objectives

In this lab you will be able to:

- Use Bayes' theorem to determine the probability of specific events

### 1.3 Define a custom function for Bayes' theorem

To start, write a function, `bayes()`, which takes in the probability of A, the probability of B, and the probability of B given A. From this, the function should then return the conditional probability of A, given that B is true.

```
[1]: def bayes(P_a, P_b, P_b_given_a):  
      # Your code here  
      P_a_given_b = P_b_given_a * P_a / P_b  
      return P_a_given_b
```

### 1.4 Skin Cancer

After a physical exam, a doctor observes a blemish on a client's arm. The doctor is concerned that the blemish could be cancerous, but tells the patient to be calm and that it's probably benign. Of those with skin cancer, 100% have such blemishes. However, 20% of those without skin cancer also have such blemishes. If 15% of the population has skin cancer, what's the probability that this patient has skin cancer?

Hint: Be sure to calculate the overall rate of blemishes across the entire population.

```
[2]: # Your code here  
  
# P_b: having blemishes:  
P_b = 1 * 0.15 + 0.2 * 0.85  
  
# P_b_given_a: having blemishes given that the patient has a skin cancer  
P_b_given_a = 1
```

```
#P_a: having cancer
P_a = 0.15

bayes(P_a, P_b, P_b_given_a)
```

[2]: 0.46875

## 1.5 Children (I)

A couple has two children, the older of which is a boy. What is the probability that they have two boys?

```
[6]: # Your solution P(2boys/older child is a boy)

# P_a: probability of 2 boys
P_a = 0.5 * 0.5

# P_b: Older kid is a boy
P_b = 0.5

#P_b_given_a: the older one is a boy given that both are boys

P_a_given_b = 1
bayes(P_a, P_b, P_b_given_a)

### From GitHub Solution

# Your solution P(2boys/older child is a boy)
P_a = 1/4 # Probability of 2 boys
P_b = .5 # Probability older child is a boy
P_b_given_a = 1 # Probability older child is a boy if 2 boys
bayes(P_a, P_b, P_b_given_a)
```

[6]: 0.5

## 1.6 Children (II)

A couple has two children, one of which is a boy. What is the probability that they have two boys?

```
[9]: # Your solution P(2boys/1 of 2 children is a boy)

# P_a: having two boys:
P_a = 1/4
```

```

# P_b: 1 of 2 children is a boy
P_b = 1/2 * 1/2 + 1/2 * 1/2 + 1/2 * 1/2

# P_b_given_a = 1 of 2 children is a boy given that they have 2 boys:

P_b_given_a = 1

print(bayes(P_a, P_b, P_b_given_a))

### From GitHub

# Your solution P(2boys/1 of 2 children is a boy)
P_a = 1/4 # Probability of 2 boys
P_b = 3/4 # Probability 1 of 2 children is a boy
P_b_given_a = 1 # Probability of 1 of 2 children being a boy, given both are
↳ boys
bayes(P_a, P_b, P_b_given_a)

```

0.3333333333333333

[9]: 0.3333333333333333

## 1.7 A diagnostic test

A diagnostic test is advertised as being 99% accurate

- If a patient has the disease, they will test positive 99% of the time
- If they don't have the disease, they will test negative 99% of the time
- 1% of all people have this disease

If a patient tests positive, what is the probability that they actually have the disease?

[10]: # Your solution P(Disease / positive test)

```

# P_a: Disease
P_a = 0.01

# P_b: Positive Test
P_b = 0.01 * 0.99 + 0.01 * 0.99

# P_b_given_a: Positive test given Disease
P_b_given_a = 0.99

bayes(P_a, P_b, P_b_given_a)

```

[10]: 0.5

## 1.8 Summary

In this lab, you practiced a few simple examples of Bayesian logic and how you can add prior information to update your beliefs about the chance of events.