Dataset Edibility Cap Shape Cap Color Odor Habitat poisonous urban convex brown pungent edible almond convex yellow grasses edible bell white anise meadows white poisonous convex pungent urban edible convex gray none grasses edible convex yellow almond grasses edible bell white almond meadows bell edible white anise meadows poisonous convex white pungent grasses bell edible yellow almond meadows edible convex yellow anise grasses edible convex meadows yellow almond yellow edible bell grasses almond poisonous convex white pungent urban edible convex brown grasses sunken edible urban gray none edible flat white none grasses poisonous convex brown pungent grasses white urban poisonous convex pungent poisonous convex brown pungent urban bell edible yellow almond meadows poisonous convex brown pungent grasses edible bell yellow anise meadows edible bell white almond meadows edible bell white anise meadows poisonous flat white pungent grasses edible convex almond meadows yellow edible convex white anise meadows edible flat urban brown none edible convex yellow almond woods bell edible yellow anise meadows poisonous white urban convex pungent edible convex yellow anise meadows edible convex brown anise paths edible bell yellow anise meadows yellow edible woods convex anise edible sunken urban gray poisonous urban convex brown pungent edible convex vellow almond woods edible bell yellow meadows anise edible bell yellow almond grasses edible paths convex yellow anise edible convex urban brown none poisonous convex white pungent grasses edible convex yellow almond meadows edible convex white almond grasses edible convex yellow anise meadows edible convex white anise meadows edible convex yellow anise paths flat edible yellow pungent paths edible convex almond brown grasses edible convex white grasses anise edible bell white anise meadows poisonous urban convex brown pungent white urban poisonous convex pungent yellow edible bell almond meadows edible flat gray none grasses edible bell grasses white almond edible convex yellow anise grasses edible convex brown almond paths edible sunken gray urban none edible bell yellow almond meadows bell edible yellow anise meadows bell edible yellow anise meadows bell edible white anise grasses flat edible brown none grasses edible convex white anise grasses flat grasses edible yellow almond edible yellow almond convex grasses edible convex gray none urban flat edible yellow anise woods edible bell white anise meadows flat edible yellow anise woods edible paths convex brown almond edible bell yellow almond grasses flat edible yellow anise woods edible white woods convex anise flat edible brown anise paths poisonous convex brown pungent urban edible flat brown almond grasses edible brown convex none grasses poisonous convex white pungent grasses edible urban gray none edible convex yellow anise grasses edible convex brown none grasses edible bell white almond grasses edible convex white anise grasses flat edible brown anise grasses edible sunken brown urban none edible convex brown none urban bell edible white anise grasses edible convex yellow almond grasses yellow edible convex anise meadows edible convex brown none grasses edible white convex almond grasses edible flat brown anise grasses edible convex almond yellow grasses bell edible white almond grasses edible white convex almond grasses edible convex brown none grasses edible bell yellow anise grasses edible flat yellow anise grasses edible convex yellow almond paths edible bell white anise grasses edible convex yellow almond meadows edible convex yellow almond grasses edible bell white anise meadows edible bell white almond meadows edible convex yellow almond meadows edible yellow anise convex grasses edible sunken urban gray none edible convex white almond woods edible yellow almond meadows convex urban poisonous convex white pungent edible yellow convex anise grasses edible urban sunken none gray edible convex yellow anise grasses edible convex yellow anise woods edible sunken brown urban none poisonous convex white pungent grasses edible convex white almond meadows flat poisonous brown pungent grasses flat edible gray none grasses edible convex yellow anise meadows edible white convex none grasses yellow edible bell almond grasses edible flat gray none edible bell white anise meadows edible bell white anise grasses bell edible white anise meadows

Variable Values

| Edible | Cap Shape | Cap Color | Odor | Habitat |
|-----------|-----------|-----------|---------|---------|
| edible | convex | brown | almond | grasses |
| poisonous | bell | gray | anise | meadows |
| | flat | white | none | paths |
| | sunken | yellow | pungent | urban |
| | | | | woods |

Recall Bayes' Theorem:

$$P(E | S, C, O, H) = \frac{P(S, C, O, H | E)P(E)}{P(S, C, O, H)}$$

In Naive Bayes, we assume that

P(S, C, O, H | E) = P(S | E)P(C | E)P(O | E)P(H | E)

Then, what is P(S, C, O, H)?

P(S, C, O, H) = P(S, C, O, H | E = e) + P(S, C, O, H | E = p)

Now, we have everything we need:

| Edibility | | Cap Shape | | Cap Color | | Odor | | Habitat | |
|-------------|-----|-----------|-----|-----------|-----|---------|-----|---------|-----|
| edible | 538 | convex | 324 | brown | 131 | almond | 221 | grasses | 254 |
| poisonous | 62 | bell | 143 | gray | 49 | anise | 205 | meadows | 148 |
| | , | flat | 111 | white | 212 | none | 111 | paths | 48 |
| Total | 600 | sunken | 22 | yellow | 208 | pungent | 63 | urban | 93 |
| Can Chana l | | | | | • | | | woods | 57 |

yellow

0

62

Cap Shape | Edibility

| | convex | bell | flat | sunken |
|-----------|--------|------|------|--------|
| edible | 268 | 143 | 105 | 22 |
| poisonous | 56 | 0 | 6 | 0 |

Cap Color | Edibility

brown

| edible | 98 | 49 | 183 | 208 | | | | |
|------------------|--------|-------|------|---------|--|--|--|--|
| poisonous | 33 | 0 | 29 | 0 | | | | |
| Odor Edibility | | | | | | | | |
| | almond | anise | none | pungent | | | | |
| edible | 221 | 205 | 111 | 1 | | | | |

gray

Habitat | Edibility

poisonous

| | grasses | meadows | paths | urban | woods |
|-----------|---------|---------|-------|-------|-------|
| edible | 227 | 148 | 48 | 58 | 57 |
| poisonous | 27 | 0 | 0 | 35 | 0 |

white

And to calculate the probabilities:

| P(Edibility) |) | P(Cap Sha | pe) | P(Cap Co | lor) | P(Odor-1) | | P(Habitat) | |
|--------------|-------|-----------|-------|----------|-------|-----------|-------|------------|-------|
| edible | 0.897 | convex | 0.540 | brown | 0.218 | almond | 0.368 | grasses | 0.423 |
| poisonous | 0.103 | bell | 0.238 | gray | 0.082 | anise | 0.342 | meadows | 0.247 |
| | | flat | 0.185 | white | 0.353 | none | 0.185 | paths | 0.080 |
| Total | 600 | sunken | 0.037 | yellow | 0.347 | pungent | 0.105 | urban | 0.155 |
| | _ | | | | | | | woods | 0.095 |

| P(Cap Shape Edibility) | | | | | | |
|--------------------------|--------|-------|-------|--------|--|--|
| | convex | bell | flat | sunken | | |
| edible | 0.498 | 0.266 | 0.195 | 0.041 | | |
| poisonous | 0.903 | 0.000 | 0.097 | 0.000 | | |

P(Cap Color | Edibility)

| | brown | gray | white | yellow | | |
|-----------|-------|-------|-------|--------|--|--|
| edible | 0.182 | 0.091 | 0.340 | 0.387 | | |
| poisonous | 0.532 | 0.000 | 0.468 | 0.000 | | |

P(Odor | Edibility)

| | almond | anise | none | pungent |
|-----------|--------|-------|-------|---------|
| edible | 0.411 | 0.381 | 0.206 | 0.002 |
| poisonous | 0.000 | 0.000 | 0.000 | 1.000 |
| | | | | |

P(Habitat | Edibility)

| | grasses | meadows | paths | urban | woods |
|-----------|---------|---------|-------|-------|-------|
| edible | 0.422 | 0.275 | 0.089 | 0.108 | 0.106 |
| poisonous | 0.435 | 0.000 | 0.000 | 0.565 | 0.000 |

Now, let's calculate an example.

Let's say we are walking in **grass**, and we see a mushroom. The mushroom has a **flat**, **white** cap, and a **pungent** smell.

What is the probability that this mushroom is **poisonous**?

In mathematical terms, what is the following?

$$P(E=p \mid S=f, C=w, O=p, H=g) \qquad \text{For brevity, I'll call it } P(p \mid f, w, p, g)$$

From Bayes' Theorem, we have:

$$P(p | f, w, p, g) = \frac{P(f, w, p, g | p)P(p)}{P(f, w, p, g)}$$

Let's calculate the top term first. We know from our assumption that it equals:

Notice how each term can be found by simply counting? We can calculate it by looking up the corresponding probability in the tables above. The values needed are highlighted in yellow.

$$P(f|p)P(w|p)P(p|p)P(g|p)P(p) \approx 0.097 \times 0.468 \times 1 \times 0.435 \times 0.103$$

 ≈ 0.002

Then the bottom term. As we have shown:

$$P(f, w, p, g) = P(f, w, p, g | e) + P(f, w, p, g | p)$$

And since we assume conditional independence between S, C, O, P given E, we have:

$$P(f, w, p, g) = P(f | e)P(w | e)P(p | e)P(g | e)P(e) + P(f | p)P(w | p)P(p | p)P(g | p)P(p)$$

We know that the second half is 0.002 - it's the same as above. What is the first half, then? We look up the table again!

The values needed are highlighted in blue.

$$P(f|e)P(w|e)P(p|e)P(g|e)P(e) \approx 0.195 \times 0.340 \times 0.002 \times 0.422 \times 0.897$$

 ≈ 0.00005

Now we can calculate the final answer!

$$P(p | f, w, p, g) = \frac{P(f, w, p, g | p)}{P(f, w, p, g | e) + P(f, w, p, g | p)}$$

$$\approx \frac{0.002}{0.00005 + 0.002}$$

$$\approx 0.976$$

Therefore, don't eat that mushroom!!!

anise

anise

woods

meadows

white

yellow

flat

edible

edible