CS-5783
Machine Learning
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Assignment 4.

⇒ Q1

Conditional probability distribution - As there are continuous values we need to use gaussian distribution, to achieve gaussian probability.

Step 1. Calculate mean wrt each feature over the particular class

Step 2. Calculate the standard deviation wrt each feature of each class.

Step 3. Calculate the conditional probability with normal distribution

$$P(x_j \mid C = c_i) = \frac{1}{\sqrt{2\pi\,\sigma_{ji}^2}}\, e^{\left(\frac{-(x_j - \mu_{ji})^2}{2\sigma_{ji}^2}\right)}$$

Here

μ_{ji} ⇒ mean of values x_j for class $C = c_i$

σ_{ji} ⇒ standard deviation of values x_j for class $C = c_i$

Calculation for bathroom:

$$\text{Apartment mean} = \frac{1+1+1+2.5+1+1.5+1}{7} = 1.28$$

$$\text{variance} = \frac{(1-1.28)^2 + (1-1.28)^2 + (1-1.28)^2 + (2.5-1.28)^2 + (1-1.28)^2 + (1.5-1.28)^2 + (1-1.28)^2}{7}$$

$$= 0.321$$

$$\text{Standard deviation} = \sqrt{\text{variance}} = \sqrt{0.321} = 0.56$$

Condo

mean $= \frac{1+1+2.5+1.5+1+1}{6} = 1.33$

variance $= \frac{(1-1.33)^2 + (1-1.33)^2 + (2.5-1.33)^2 + (1.5-1.33)^2 + (1-1.33)^2 + (1-1.33)^2}{6}$

$= 0.366 \Rightarrow$ Standard deviation $= \sqrt{\text{variance}} = 0.60$

$\Rightarrow$ House

mean $= \frac{1+1+1+1+1+1+1.5}{7} = 1.07$

variance $= \frac{(1-1.07)^2 + (1-1.07)^2 + (1-1.07)^2 + (1-1.07)^2 + (1-1.07)^2 + (1-1.07)^2 + (1.5-1.07)^2}{7}$

$= 0.035 \Rightarrow$ Standard deviation $= \sqrt{0.035} = 0.188$

Apartment	condo	house
$\mu = 1.28$	$\mu = 1.33$	$\mu = 1.07$
$\sigma = 0.56$	$\sigma = 0.60$	$\sigma = 0.188$

Conditional probability $\left(\frac{-(x_j - \mu_{ji})^2}{2\sigma_{ji}^2} \right)$

$$P(x_j \mid C = c_i) = \frac{1}{\sqrt{2\pi\sigma_{ji}^2}} e$$

from the test set Bathroom 1, 1.5

$$P(1/c = \text{apartment}) = \frac{1}{\sqrt{2\pi \times 0.56^2}} \cdot e^{\left(-\frac{(1-1.28)^2}{2\times 0.56^2}\right)} = 0.62$$

$$P(1.5/c = \text{apartment}) = \frac{1}{\sqrt{2\pi \times 0.56^2}} e^{\left(-\frac{(1.5-1.28)^2}{2\times 0.56^2}\right)} = 0.65$$

$$P(1/c = \text{condo}) = \frac{1}{\sqrt{2\pi \times 0.6^2}} e^{\left(-\frac{(1-1.33)^2}{2\times 0.6^2}\right)} = 0.57$$

$$P(1.5/c = \text{condo}) = \frac{1}{\sqrt{2\pi \times 0.6^2}} e^{\left(-\frac{(1.5-1.33)^2}{2\times 0.6^2}\right)} = 0.63$$

$$P(1/c = \text{House}) = \frac{1}{\sqrt{2\pi \times 0.18^2}} e^{\left(-\frac{(1-1.07)^2}{2\times 0.18^2}\right)} = 1.97$$

$$P(1.5/c = \text{House}) = \frac{1}{\sqrt{2\pi \times 0.18^2}} e^{\left(-\frac{(1.5-1.07)^2}{2\times 0.18^2}\right)} = 0.55$$

Calculations for the rooms available:

$$\text{Apartment mean} = \frac{7+8+5+6+9+6+7}{7} = 6.85$$

$$\text{variance} = \frac{(7-6.85)^2 + (8-6.85)^2 + (5+6.85)^2 + (6+6.85)^2 + (9-6.85)^2 + (6-6.85)^2 + (7-6.85)^2}{7}$$

$$= 1.80$$

$$\text{standard deviation} = \sqrt{1.80} = 1.34$$

Cardiostand

$$\text{mean} = \frac{6+7+10+6+6+6}{6} = 6.83$$

$$\text{Variance} = \frac{(6-6.83)^2 + (7-6.83)^2 + (6-6.83)^2 + (10-6.83)^2 + (6-6.83)^2 + (6-6.83)^2}{6}$$

$$= 2.56.$$

$$\text{Standard deviation} = \sqrt{2.56} = 1.60$$

$$\text{House mean} = \frac{6+6+6+5+6+7+7}{7} = 6.14$$

$$\text{var} = \frac{4(6-6.14)^2 + (5-6.14)^2 + 2(7-6.14)^2}{7}$$

$$= 0.47$$

$$\text{Standard deviation} = \sqrt{0.47} = 0.69$$

Apartment	Cardo	House
$\mu = 6.85$	$\mu = 6.83$	$\mu = 6.14$
$\sigma = 1.34$	$\sigma = 1.60$	$\sigma = 0.69$

Conditional probability

$$P(X_i | C = apt) = \frac{1}{\sqrt{2\pi + \mu_{ij}^2}} e^{-\left(\frac{(X_j - \mu_{ij})^2}{2\sigma_{j,i}}\right)}$$

$$P(6 | C = apt) = 0.24, \quad P(7 | C = apt) = 0.29$$

$$P(8 | C = apt) = 0.20$$

$P(6 \mid c = \text{condo}) = 0.21 \quad P(7 \mid c = \text{condo}) = 0.24$

$P(8 \mid c = \text{condo}) = 0.19$

$P(6 \mid c = \text{House}) = 0.56 \quad P(7 \mid c = \text{House}) = 0.26$

$P(8 \mid c = \text{House}) = 0.015$

Local price.

Apartment	Condo	House
mean = 7.33	mean = 7.41	mean = 5.76
var = 13.07	var = 21.26	var = 0.32
SD = 3.61	SD = 4.61	SD = 0.57

$P(6.0931 \mid c = \text{Apt}) = 0.104$

$P(8.3607 \mid c = \text{apt}) = 0.106$

$P(8.14 \mid c = \text{apt}) = 0.107$

$P(9.1416 \mid c = \text{apt}) = 0.077$

$P(12 \mid c = \text{apt}) = 0.047$

$P(6.093 \mid c = \text{condo}) = 0.083$

$P(8.3607 \mid c = \text{condo}) = 0.084$

$P(8.14 \mid c = \text{condo}) = 0.085$

$P(9.1416 \mid c = \text{condo}) = 0.080$

$P(12 \mid c = \text{condo}) = 0.52$

$P(6.093 \mid C = \text{House}) = 0.5$

$P(8.3607 \mid C = \text{House}) = 2.1 \times 10^{-5}$

$P(8.14 \mid C = \text{House}) = 1 \times 10^{-4}$

$P(9.1416 \mid C = \text{House}) = 1.59 \times 10^{-8}$

$P(12 \mid C = \text{House}) = 6.62 \times 10^{-27}$

Land area

Apartment	Condo	House
$\mu = 6.10$	$\mu = 6.024$	$\mu = 6.6309$
$SD = 3.25$	$SD = 2.54$	$SD = 2.24$

$P(6.7265 \mid C = \text{apartment}) = 0.12$

$P(9.15 \mid C = \text{apt}) = 0.07$

$P(8 \mid C = \text{apt}) = 0.103$

$P(7.326 \mid C = \text{apt}) = 0.114$

$P(5 \mid C = \text{apt}) = 0.115$

$P(6.7265 \mid C = \text{Condo}) = 0.15$

$P(9.15 \mid C = \text{condo}) = 0.07$

$P(8 \mid C = \text{condo}) = 0.116$

$P(7.326 \mid C = \text{condo}) = 0.137$

$P(5 \mid C = \text{condo}) = 0.144$

$P(9.15 \mid C = \text{House}) = 0.09$

$P(8 \mid C = \text{House}) = 0.14$

$P(-7.3262 \mid C = \text{House}) = 0.16$

$P(5 \mid C = \text{House}) = 0.13$

Living area,

Apartment	Condo	House
$\mu = 1.505$	$\mu = 1.553$	$\mu = 1.391$
$SD = 0.836$	$SD = 0.96$	$SD = 0.46$

$P(1.652 \mid C = \text{Apt}) = 0.55$

$P(1.777 \mid C = \text{apt}) = 0.52$

$P(1.504 \mid C = \text{apt}) = 0.56$

$P(1.831 \mid C = \text{apt}) = 0.50$

$P(1.2 \mid C = \text{apt}) = 0.51$

$P(1.652 \mid C = \text{condo}) = 0.429$

$P(1.777 \mid C = \text{condo}) = 0.419$

$P(1.504 \mid C = \text{condo}) = 0.431$

$P(1.831 \mid C = \text{condo}) = 0.413$

$P(1.21 \mid C = \text{condo}) = 0.401$

$P(1.652 \mid C = \text{House}) = 0.88$

$P(1.777 \mid C = \text{House}) = 0.35$

$P(1.504 \mid C = \text{House}) = 1.63$

$P(1.831 \mid C = \text{House}) = 0.2$

$P(1.21 \mid C = \text{House}) = 1.2$

Garages.

Apt	condo	house.
$\mu = 1.21$	$\mu = 1.33$	$\mu = 1.07$
$\sigma = 0.69$	$\sigma = 0.51$	$\sigma = 0.83$

$P(1 \mid c=apt) = 0.552$

$P(1.5 \mid c=apt) = 0.529$

$P(2 \mid c=apt) = 0.300$

$P(1 \mid c=condo) = 0.63$

$P(1.5 \mid c=condo) = 0.73$

$P(2 \mid c=condo) = 0.33$

$P(1 \mid c=house) = 0.47$

$P(1.5 \mid c=H) = 0.42$

$P(2 \mid c=H) = 0.25$

Bedrooms.

Apartment	condo	House
$\mu = 3.42$	$\mu = 3.33$	$\mu = 3$
$\sigma = 0.97$	$\sigma = 0.81$	$\sigma = 0.57$

$P(3 \mid c = apt) = 0.37$

$P(4 \mid c = apt) = 0.34$

$P(3 \mid c = condo) = 0.45$

$P(4 \mid c = condo) = 0.34$

$P(3 \mid c = house) = 0.69$

$P(4 \mid c = house) = 0.15$

Age of home.

Apt	Condo
$\mu = 38.71$	$\mu = 39.66$
$\sigma = 14.68$	$\sigma = 13.95$

House

$\mu = 34.28$

$\sigma = 12.72$

$P(44 \mid c = apt) = 0.025$

$P(48 \mid c = apt) = 0.022$

$P(31 \mid c = apt) = 0.023$

$P(30 \mid c = apt) = 0.022$

$P(44 \mid c = condo) = 0.027$

$P(48 \mid c = condo) = 0.023$

$P(31 \mid c = condo) = 0.02$

$P(30 \mid c = condo) = 0.022$

$P(44 \mid c = house) = 0.023$

$P(48 \mid c = house) = 0.017$

$P(31 \mid c = house) = 0.030$

$P(30 \mid c = house) = 0.029$