Chi-Squared Test for Machine Learning

Supplementary Lecture

Outline

- What is Chi-square statistics
- Applications in Machine learning
- Example

Chi-square Statistics

- A chi-square statistic is one way to show a relationship between two categorical variables
- The chi-squared statistic is a single number that tells you how much difference exists between your observed counts and the counts you would expect if there were no relationship at all in the population.
- The chi-square distribution can be represented as

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Chi-Square Statistics

- The chi-square distribution can be represented as

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

- If there is no difference in observed and expected frequencies, then the chi-square value would be zero. If there is a difference, then the value of chi-square would be more than zero.
- The subscript c represents degree of freedom- the maximum number of independent values

Chi square statistics

- Chi-square test is used to test the ***goodness of fit***
  - determines if a sample data matches a population
- A chi-square **test for independence compares** two variables in a contingency table to see if they are related
  - A very small chi square test statistic means that your observed data fits your expected data extremely well. In other words, there is a relationship.
  - A very large chi square test statistic means that the data does not fit very well. In other words, there isn’t a relationship.

Chi-Square Statistics

- Whether input features are relevant to the outcome to be predicted
- Whether the class (target variable) is dependent or independent on the input features (variable)
    - If independent, we can say the feature is irrelevant in modeling the target class and can be removed **(Feature selection)**

Contingency Table

- Pairs of categorical values can be summarized using **contingency table**
- It shows the distribution of one variable in rows and another in columns
- Example:

Exited\ Gender	Yes	No	Total
Male	38	178	216
Female	44	140	184
Total	82	318	400

Chi square Test

Consider a data-set where we have to determine why customers are leaving the bank,

Let’s perform a Chi-Square test for two variables.

Gender of a customer with values as Male/Female as the predictor and Exited describes whether a customer is leaving the bank with values Yes/No as the response. In this test we will check is there any relationship between Gender and Exited.

Chi square Test

Dataset →

	Gender	……….	Exited
1	Male	……….	Yes
2	Male	……….	Yes
3	Female	……….	No
4	Male	……….	Yes
5	Male	……….	No
6	Male	……….	No
.	.	……….	.
.	.	……….	.
400	Female	……….	No

Chi square Test

Steps to perform the Chi-Square Test:

1. Define Hypothesis.
2. Build a Contingency table.
3. Find the expected values.
4. Calculate the Chi-Square statistic.
5. Accept or Reject the Null Hypothesis

Chi square Test

Define Hypothesis

- Null Hypothesis (H0): Two variables are independent.
- Alternate Hypothesis (H1): Two variables are not independent.

Chi square Test

Contingency Table

- Compute the contingency table

Exited\ Gender	Yes	No	Total
Male	38	178	216
Female	44	140	184
Total	82	318	400

	Gender	....	Exited
1	Male	....	Yes
2	Male	....	Yes
3	Female	....	No
4	Male	....	Yes
5	Male	....	No
6	Male	....	No
.	.	....	.
.	.	....	.
400	Female	....	No

- DoF = (2-1) =1

Chi square Test

Find the Expected Value

- $E_{ij} = (T_i * T_j) / N$
  - T_i = Total in i^{th} row
  - T_j = Total in j^{th} column

- $E_{11} = (216 * 82)/400 = 44.24$
- $E_{12} = (216 * 318)/400 = 171.72$
- $E_{21} = (184 * 82)/400 = 37.72$
- $E_{22} = (184 * 318)/400 = 146.28$

Exited\ Gender	Yes	No	Total
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Chi square Test

Exited\Gender	Yes	No	Total
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Compute chi-square statistics

	O_i	E_i	$(O_i-E_i)^2/E_i$
1,1	38	44.24	0.880
1,2	178	171.72	0.23
2,1	44	37.72	1.045
2,2	140	146.28	0.27
$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$			2.425

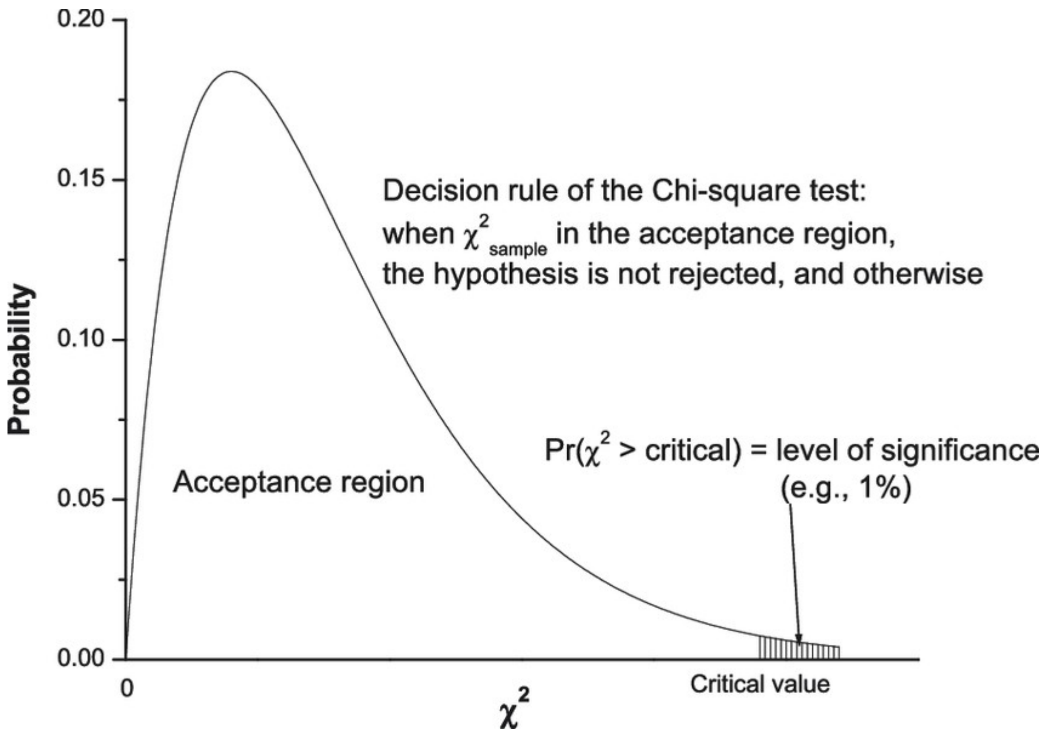
	Yes	NO
Male	44.24	171.72
Female	37.72	146.28

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

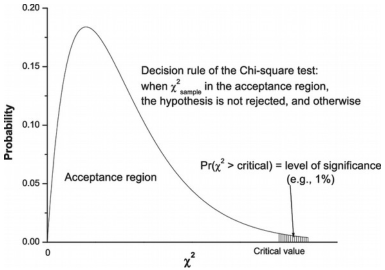
Chi square Test

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Accept or reject the Hypothesis



Chi square Test



$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Accept or reject the Hypothesis

- Compute Chi-square$_{tabulated}$ from Chi-Square table, with level of significance = 0.05 and DoF=1

Table of Chi-square statistics

t-statistics
F-statistics with other P-values: P=0.05 | P=0.01 | P=0.001

df	P = 0.05	P = 0.01	P = 0.001
1	3.84	6.64	10.83
2	5.99	9.21	13.82
3	7.82	11.35	16.27
4	9.49	13.28	18.47
5	11.07	15.09	20.52
6	12.59	16.81	22.46
7	14.07	18.48	24.32
8	15.51	20.09	26.13
9	16.92	21.67	27.88
10	18.31	23.21	29.59

Chi square Test

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Accept or reject the Hypothesis

- Compute Chi-square$_{tabulated}$ from Chi-Square table, with level of significance = 0.05 and DoF=1
- Chi-square$_{tabulated}$ =3. 84
- Chi-square$_{computed}$= 2.425
- Chi-square$_{computed}$< Chi-square$_{tabulated}$

	O_i	E_i	$(O_i-E_i)^2/E_i$
1,1	38	44.24	0.880
1,2	178	171.72	0.23
2,1	44	37.72	1.045
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		Chi square	2.425

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Chi square Test

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		Chi square	2.425

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Accept or reject the Hypothesis

- Accepting the null hypothesis since the Chi-square$_{\text{computed}}$ < Chi-square$_{\text{tabulated}}$
- That means, the variables are independent
- Gender variable cannot be selected for training the model.

Chi square Test

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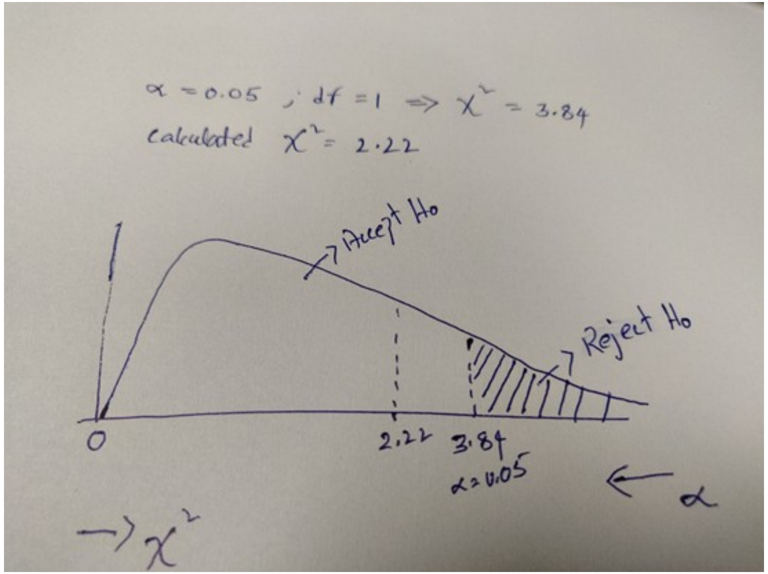

References

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https://machinelearningmastery.com/chi-squared-test-for-machine-learning/