Empirical Methods for Artificial Intelligence: Chapter 7: Explaining Performance: Interactions and Dependencies

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Outline

1. Introduction
2. ANOVA
3. Contingency Table Analysis
4. Summary

Why the obtained performance?

- Rarely a single factor is enough
- Multifactors
- Interraction effects
- Multifactors experiment

You can demonstrate relationships with one factor experiments, BUT you usually need two or more factors, and interactions, to explain relationships.

Strategies

- Independant vs Dependant
- Continuous vs Categorical
- In manipulation experiment: Independent = Manipulated, Dependent = Measured
- In observation experiment: Independent = causally "prior" to Dependent

Dep. var. Ind. var.	cont.	disc.
cont.	MR	N-Way ANOVA
disc.		CTA

Graph, a good start to study interactions

- performance variable P on y
- a factor F1 on x
- add another factor F2
- plot all mean levels of F1 for all for each combination of levels of the factors F1 and F2
- IF THE LINES AREN'T PARALLEL, THE FACTORS INTERACT.

BUT

graph is not enough -> ANOVA

1-Way ANOVA

- Divide sample variance S^2 into two components
- $S^2 = S_{noise} + S_{effect}$
- S_{noise} = mean of variances
- S_{effet} = variance of means

2-Way ANOVA

same logic -> divide into four components:

1. main effect of Factor 1 (MS_{rows})
2. main effect of Factor 2 ($MS_{columns}$)
3. effect of noise (MS_{within})
4. effect of interaction ($MS_{interaction}$)

If Interactions -> 2-Way ANOVA BUT if effects are additive 2 1-Way ...

How to

- Mean Squares = Sum of Squares divided by df (Table 7A.6)
- F Statistics:
  - MS_{rows} / MS_{within}
  - $MS_{columns} / MS_{within}$
  - $MS_{interactions} / MS_{within}$
- and p-values

Different Graphs

(cf p255)

1. no interaction effects, additive effects
2. no interaction, B no effect
3. nothing
4. main effect of A, small effect of B, and interactions
5. inverse, and interactions
6. both effects, and interactions

3-Way

same logic

- 3 main effects
- 3 2-way interactions
- 1 3-way interactions
- and the noise

Explaining Performance: 3 common aspects

- Looking for no effect (Is parallel or not?)
- Bad significance (1Way -> 2Way $MS_{within} = MS_{newfactor} + MS_{interactions} + MS_{within}$)
- explaining non-linear effect (interaction -> Transform data and model)

ANOVA Assumptions

- populations are normal
- variances of the populations are equal
- interaction and noise are independent of the other factors (repeated measures design -> learning)

or Analysis of frequencies

- natural representation of joint distribution of events
- often in sequences (execution traces):
- patterns : tit-for-tat, mediation, action at a distance, escalation

The contingency table

$$\begin{array}{cc} (f_{ij}) & \sum_j = f_i \\ \sum_i = f_j & \sum_{iandj} = f \end{array}$$

- a table = onw hypothesis
- $G = 2 \sum_{cells} f_{ij} \ln \left(\frac{f_{ij}}{\hat{f}_{ij}} \right)$
- expected frequency $\hat{f}_{ij} =$
  - extrinsically: G test is a test of goodness of fit to an extrinsic frequency distribution
  - row and column variables are independent: it is a test of independence or heterogeneity

$$\hat{f}_{ij} = \frac{f_i f_j}{f}$$

Dependency Detection for Two-Item Precursor

1. Test Packed Table Test Hetereogeneity (G*H) for each row
2. Unpack and Test Hetereogeneity (GH) for each row
3. Test the goodness of fit of each row of the unpacked table to the marginal column frequencies of the packed table

$$GT = GH + G * H$$

-> Summarize each computed G and explain

3-Way Contingency Table

use a third factor rather than unpack

Hypothesis:

- Complete Independence
- One-factor independence
- Conditional independence
- homogeneous association
- complete dependence

Complete Independence

$\hat{f_{ijk}} = \frac{f_i f_j f_k}{f^2}$
=> G

- if FAIL -> One-factor independence (2 factors are fixed)
- if FAIL -> Conditional independence (3 factors are fixed)
- if FAIL -> Homegeneous Association (see paper)

Summary

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