COSI-230B: Natural Language Annotation for Machine Learning

Lecture 9: Inter-Annotator Agreement II

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Today's Agenda

1. Review of Cohen's Kappa
2. Fleiss' Kappa (multiple annotators)
3. Krippendorff's Alpha
4. Agreement for sequence labeling (spans)
5. Agreement for rankings
6. Human-LLM agreement
7. LLM self-consistency

Review: Cohen's Kappa

For two annotators:

$$\kappa = \frac{A_o - A_e}{1 - A_e}$$

Limitations:

- Only works for exactly 2 annotators
- Assumes same 2 annotators for all items
- Categorical labels only

Today: Extensions for more complex scenarios

Fleiss' Kappa: Multiple Annotators

When you have 3+ annotators

Same formula structure:

$$\kappa = \frac{\bar{P} - \bar{P}_e}{1 - \bar{P}_e}$$

Key differences from Cohen's:

- Works with any number of annotators
- Different annotators can label different items
- More complex calculation of expected agreement

Assumption: Fixed number of annotators per item (e.g., always 3)

Fleiss' Kappa Calculation

For n items, k categories, r annotators per item:

Let n_{ij} = number of annotators who assigned item i to category j

Per-item agreement:

$$P_i = \frac{1}{r(r-1)} \sum_{j=1}^{k} n_{ij}(n_{ij} - 1)$$

Mean observed agreement:

$$\bar{P} = \frac{1}{n} \sum_{i=1}^{n} P_i$$

Expected agreement:

$$\bar{P}_e = \sum_{j=1}^{k} p_j^2$$

where p_j = proportion of all ratings in category j

Fleiss' Kappa Example

10 items, 3 categories, 4 annotators each

Item	Cat A	Cat B	Cat C	P_i
1	4	0	0	1.00
2	3	1	0	0.50
3	2	2	0	0.33
4	0	4	0	1.00
5	1	2	1	0.17
Totals	...	...	...	

Use Python: `statsmodels.stats.inter_rater.fleiss_kappa`

Or `nltk.metrics.agreement`

Krippendorff's Alpha

Most flexible agreement measure

Advantages:

- Any number of annotators
- Missing data allowed
- Works with different data types:
  - Nominal (categories)
  - Ordinal (rankings)
  - Interval (ratings)
  - Ratio (measurements)

$$\alpha = 1 - \frac{D_o}{D_e}$$

Where D_o = observed disagreement, D_e = expected disagreement

Krippendorff's Alpha: Key Features

Different distance functions:

- **Nominal:** $d^2 = 0$ if same, 1 if different
- **Ordinal:** d^2 based on rank distance
- **Interval:** $d^2 = (c - k)^2$
- **Ratio:** $d^2 = \frac{(c-k)^2}{(c+k)^2}$

Interpretation:

- $\alpha = 1$: Perfect agreement
- $\alpha = 0$: Agreement equals chance
- $\alpha < 0$: Systematic disagreement

Guideline: $\alpha > 0.8$ reliable, $\alpha > 0.67$ acceptable

Agreement for Sequence Labeling

NER and span annotation require special measures

Two approaches:

1. **Token-level:** Treat each token as a classification
   - Use standard Kappa on BIO labels
   - Doesn't capture span-level structure
2. **Entity-level:** Compare extracted spans
   - Precision/Recall/F1 between annotators
   - Exact match vs. partial match

Entity-Level Agreement

Comparing annotator spans:

Exact match:

- Spans must have identical boundaries AND type
- Strict but clear

Partial match (relaxed):

- Allow some boundary variation
- More forgiving of minor differences

Metrics:

$$P = \frac{|A \cap B|}{|A|}, \quad R = \frac{|A \cap B|}{|B|}, \quad F_1 = \frac{2PR}{P + R}$$

Where A = spans from annotator 1, B = spans from annotator 2

Agreement for Rankings

For preference annotation:

Pairwise agreement:

- Do annotators agree on which is better?
- Simple percentage or Kappa

Rank correlation:

- **Spearman's ρ:** Correlation of rank positions
- **Kendall's τ:** Proportion of concordant pairs

For RLHF:

- Often use simple majority vote
- Low agreement may be acceptable (captures preference diversity)

Human-LLM Agreement

New measure: How well does LLM match human annotation?

Calculate same as human-human:

- LLM as “annotator 2”
- Compute Kappa, F1, etc.

What to measure:

- LLM vs. single human annotator
- LLM vs. gold standard (adjudicated)
- LLM vs. majority vote

Interpretation:

- High agreement: LLM suitable for task
- Low agreement: Need human annotation

LLM Self-Consistency

Does the LLM agree with itself?

Method:

1. Run same prompt multiple times
2. Compare outputs across runs
3. Calculate agreement metrics

Why it matters:

- High consistency: Reliable (though not necessarily correct)
- Low consistency: Unreliable, needs human review

Use for confidence estimation:

- If LLM gives same answer 10/10 times: high confidence
- If LLM varies across runs: route to human

Choosing the Right Measure

Scenario	Recommended Measure
2 annotators, categories	Cohen's Kappa
3+ annotators, categories	Fleiss' Kappa
Variable annotators, categories	Krippendorff's Alpha
Ordinal ratings	Krippendorff's Alpha (ordinal)
Sequence labeling	Token Kappa + Entity F1
Rankings	Kendall's τ
Human-LLM comparison	Same as human-human

Python Tools for IAA

Libraries:

- `sklearn.metrics.cohen_kappa_score` – Cohen's Kappa
- `statsmodels.stats.inter_rater` – Fleiss' Kappa
- `krippendorff` – Krippendorff's Alpha (pip install)
- `nltk.metrics.agreement` – Multiple measures
- `scipy.stats.kendalltau` – Rank correlation

NLTK AnnotationTask:

- Flexible input format
- Multiple agreement metrics
- Handles missing data

Reporting Multi-Annotator Agreement

What to include:

1. Number of annotators
2. Number of items
3. Agreement metric used (and why)
4. Agreement value with interpretation
5. Per-category breakdown if applicable
6. Comparison to baselines or prior work

Example:

"Three annotators labeled 200 sentences. Fleiss' Kappa was 0.68, indicating substantial agreement. Per-category F1: PER=0.85, ORG=0.72, LOC=0.78."

Next Class: IAA & Modeling Introduction

Lecture 10: IAA Wrap-up — Modeling Introduction

Note: No class April 1 (Passover)

Topics:

- Resolving annotator disagreements
- Adjudication strategies
- Creating gold standard datasets
- LLM-assisted adjudication
- Introduction to modeling with annotated data

Assignment: HW 3 due

Key Takeaways

1. **Fleiss' Kappa** extends Cohen's to multiple annotators
2. **Krippendorff's Alpha** is most flexible (any data type, missing data)
3. **Span agreement** needs both token and entity-level measures
4. **Ranking agreement** uses correlation measures
5. **Human-LLM agreement** validates LLM annotation quality
6. **LLM self-consistency** can indicate confidence

Questions?

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Office Hours: Wednesdays 1-3pm, Volen 109

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