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Inter-Annotator Agreement and the Upper Bound on System Performance in Biomedical and General Domain Natural Language Processing

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Background and the Problem

Is categorization reproducible and reliable?

Jacob Cohen (clinical-social-personality areas of psychology) quantified reproducibility and reliability as having ≥2 independent judges categorize a sample and determine degree, significance, and sampling stability of their agreement.

Cohen's Kappa[1]: Pr(a) - probability that the 2 annotators agree, Pr(e) - probability that the annotators agree by chance.

$$\mathrm{K} = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)}$$

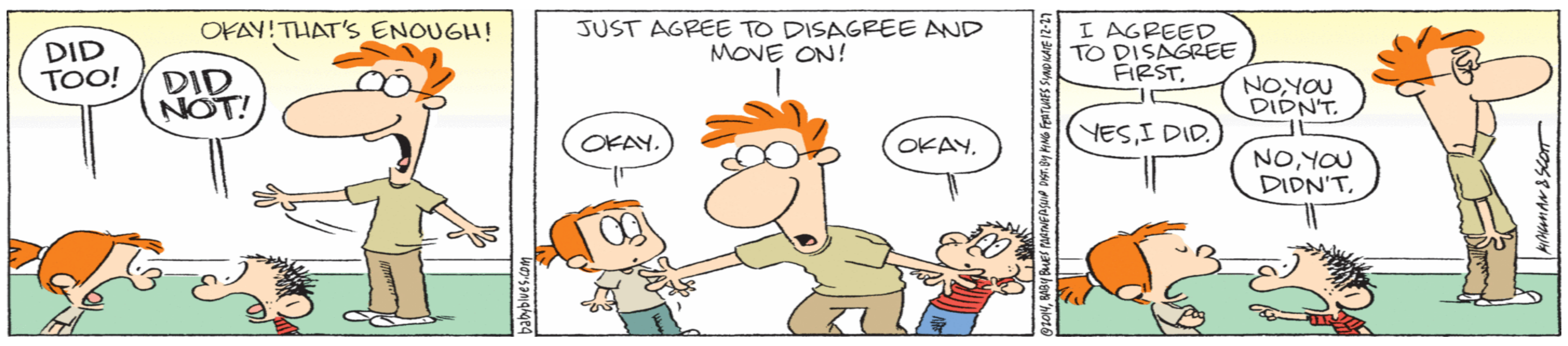
Natural Language Processing (NLP), specifically Machine Learning[2]:

We use data labeled by humans (annotators) with correct answers to train and validate categorization algorithms. We then compare the computer performance against the **Inter-Annotator Agreement (IAA)** score: how often do 2 annotators agree about the classification of the same text? Cohen's Kappa is one quantification of the IAA for 2 annotators (Fleiss's Kappa for more than 2). To compare to computer performance, use precision, recall, or F1-measure.

The Problem:[3-8]

It's often thought that the IAA (agreement between annotators) is the upper limit on how well a system can perform: if humans can't agree with each other about the classification more than some percentage of the time, then it's not reasonable to expect a computer to do any better. In fact though, the IAA is not an upper bound on system performance in NLP in both the biomedical and general domains.

Agreeing to Disagree[9]


DID TOO!
DID NOT!
OKAY! THAT'S ENOUGH!
babyblues.com
JUST AGREE TO DISAGREE AND MOVE ON!
OKAY.
OKAY.
©2014, BABY BLUES PARTNERSHIP DIST. BY KING FEATURES SYNDICATE 12-27
I AGREED TO DISAGREE FIRST.
YES, I DID.
NO, YOU DIDN'T.
NO, YOU DIDN'T.
KIRKMAN & SCOTT

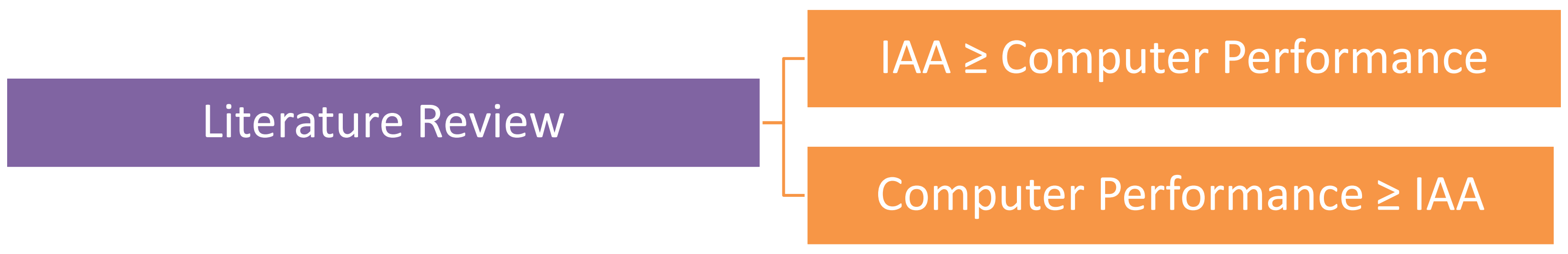
Methods and Materials

Methods:

If the assumption is true that IAA is the upper bound on computers, then there should not be findings of system performance higher than the IAA in the literature. We know about system performance to the extent that it gets published, so we did a literature review.

Materials:

Conference papers, Journal articles, natural language processing books


Literature Review

IAA ≥ Computer Performance

Computer Performance ≥ IAA

IAA Scores

Interpretation of IAA[2]:

A measure for how hard a problem is. High IAA score indicates the task is well-defined and other annotators will be able to continue the work (reproducible).

Note: Having a high IAA only means the annotators interpreted the instructions consistently in the same way, it does not mean that annotations are correct. In general, annotators are probably the most variable part of an annotation.

K	Agreement Level
<0	Poor
0.01-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Perfect

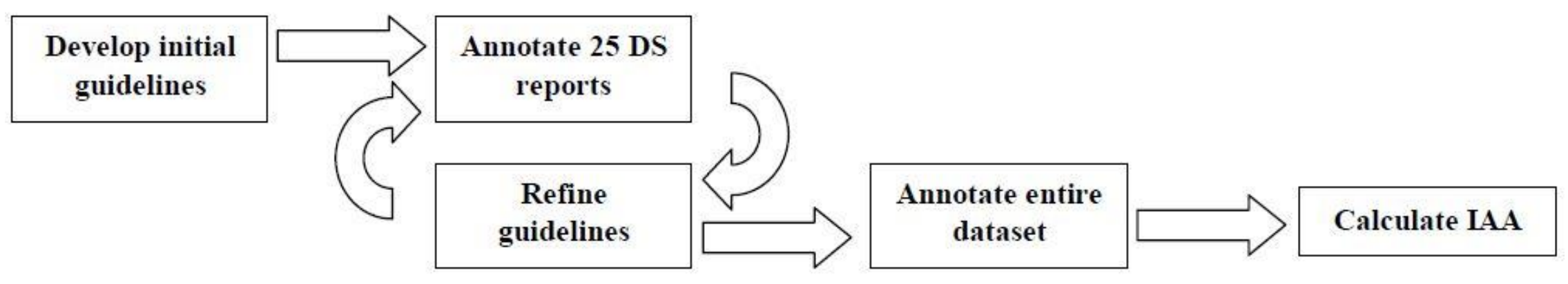
Examples of Computers Outperforming Human Annotators

Biomedical Examples:

- *Combining Terminology Resources and Statistical Methods for Entity Recognition: an Evaluation*[10]
  a) Machine learning to recognize specific entities within clinical notes
  b) F1 measure vs. IAA: classifying intervention had lowest IAA and F1 ≥ IAA with multiple methods
- *Disambiguation of Occurrences of Reformulation Markers*[11]
  a) Reformulation vs. non-reformulation in French with specific markers
  b) 2 annotators for ESLO1/2 (spoken scenarios) and hypertension illness/life forum (hybrid of spoken and written language)

Corpus	Agreement (Cohen's Kappa)	Interpretation	Precision
ESLO1	0.617	Substantial	0.630
ESLO2	0.526	Moderate	0.664
Forum	0.784	Substantial	0.752

- *SemEval-2015 Task 6: Clinical TempEval*[12]
  a) Systems compete to identify critical timeline components of clinical notes and pathology reports from the Mayo Clinic
  b) **IAA1** between 2 independent annotators (Kappa statistic)
  c) **IAA2** between adjudicator and 2 annotators
  d) Many systems F1 ≥ IAA1 and a few better than IAA2 (stronger)
- *Automatically Detecting Acute Myocardial Infarction (AMI) Events from EHR Text: a Preliminary Study*[13]
  a) Automate the annotation of Worcester Heart Attack Study for AMI
  b) Annotation process: iterative and complex

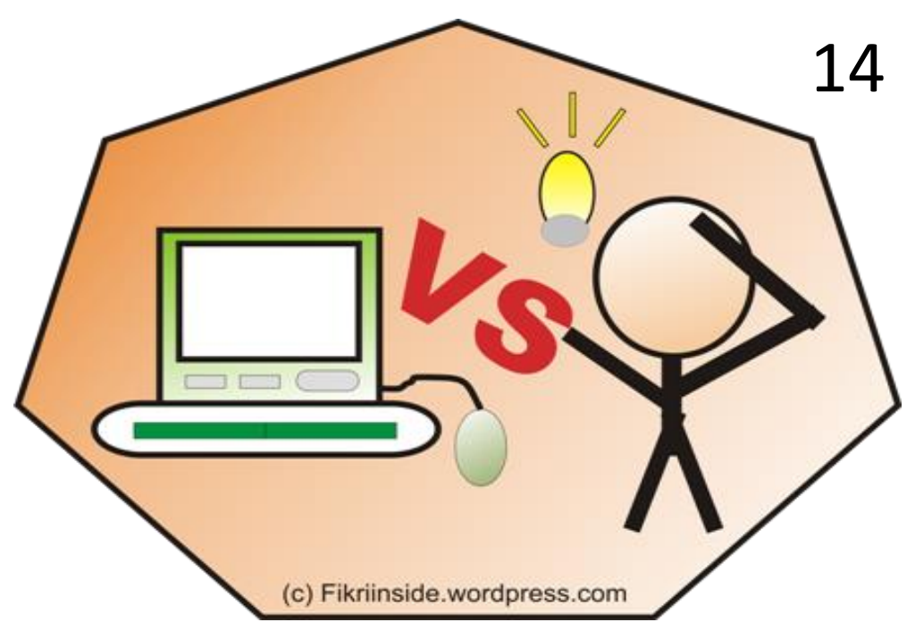


  c) F1 of system for ICD Diagnosis outperformed the IAA

Conclusions

1. IAA is not an upper bound of system performance
2. Low IAA leads investigators to not trust annotators or provides evidence that the task is difficult for humans
3. IAA2 (adjudicator-annotators) may be a better upper bound since this includes the data analyzed

Computer ≥ IAA!



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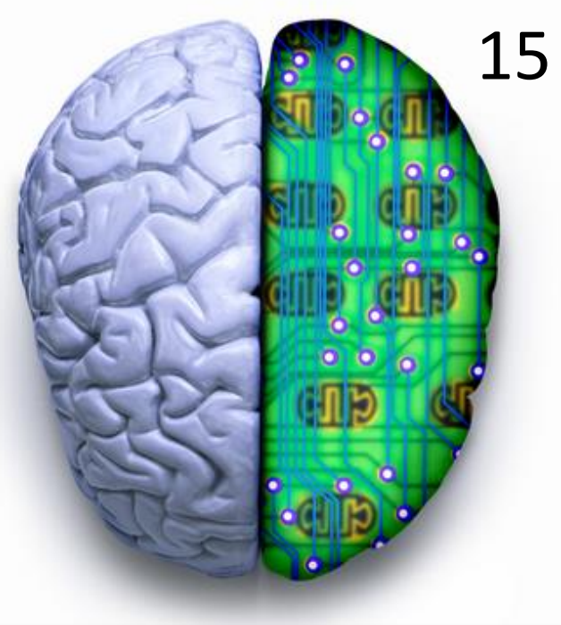

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