NIST

iTL Information Technology Laboratory

Use of Interval Quantifications

for the Value of Forensic Evidence

Steve Lund & Hari Iyer

April 1, 2016

Technical Colloquium:
Quantifying the weight of forensic evidence
May 5-6, 2016, NIST.

Disclaimer(s)

Points of view in this presentation do not necessarily represent the official position or policies of the Statistical Engineering Division, the National Institute of Standards and Technology or the U.S. Department of Commerce.

All errors are to be blamed on Steve. Any good idea is purely an accidental happening.

Today we are being Bayesians. So the subjective nature of probabilities will not be discussed or debated.

How To Quantify Weight of Evidence?

- **I assert that LR is the right way to quantify the weight of evidence.**

How To Quantify Weight of Evidence?

- **I assert that LR is the right way to quantify the weight of evidence.**
- **I assert that LR is the wrong way to quantify the weight of evidence.**

Explanation

- A TOF will have certain **prior odds** regarding the truth of a proposition (H_p, say), before becoming aware of evidence E.
- This TOF will have certain **posterior odds** after becoming aware of E.
- LR (Bayes Factor) is **defined** as

$$\boxed{LR \textbf{ for TOF} = \frac{\textbf{Posterior Odds for TOF}}{\textbf{Prior Odds for that TOF}}.}$$

- Posterior Odds of **TOF** = LR of **TOF** $\times$ Prior Odds of **TOF**
- Given any two of these quantities, the third quantity HAS TO SATISFY the above relationship.

Two Ways To Get Posterior Odds

Posterior Odds of TOF) = (LR of TOF) $\times$ (Prior Odds of TOF)

- A TOF may directly assess their posterior odds after being exposed to E,
  OR
- they may first evaluate their prior odds, then evaluate THEIR LR, and finally calculate their posterior odds.
- Is one approach better than the other?
- One would like to think that stating the prior odds, then calculating LR, then using Bayes Rule to calculate their posterior odds, will lead to **better** decisions.
- Has this ever been demonstrated?

Square Peg, Round Hole

Posterior Odds of TOF) = (LR of TOF) $\times$ (Prior Odds of TOF)

- If you ask a decision maker to specify all three quantities separately, it is highly unlikely that their stated values will satisfy Bayes Rule.
- I am not aware of studies that have tested this but I wouldn't be surprised if Kahneman/Tversky or Gigerenzer or Bill Thompson have conducted such studies and know the answer.
- My guess is, and I am willing to bet a good chunk of money, that Bayes Rule will NOT be satisfied.
- What does that mean? That means, the decision maker needs to **revise** one or more of their stated subjective probabilities in the interest of rationality and coherence.
- Somehow one has to modify the square peg to fit into a round hole.

Hybrid Bayes Rule for Forensic Science Applications??

- So things are not easy as it is. But now see what the forensic scientists community is facing.
- We are, in essence, saying that LR of TOF should be substituted with LR of FE.
- That is, **FE is TELLING THE TOF** what their probabilities ought to be.

Hybrid Bayes Rule for Forensic Science Applications??

- The reason we give is that TOF are incapable (let us not argue this point) and FE are experts who are trained to **KNOW** what the subjective probabilities of the TOF should be.
- We are then, in effect, modifying Bayes Rule as follows:

$$\textbf{Posterior Odds for TOF} = LR \textbf{ for FE} \times \textbf{Prior Odds for TOF}$$

- Remember that we argue for the use of LR on the basis of rationality and coherence.
- **I wonder why the conveniently modified Bayes Rule would satisfy the rationality and coherence requirements. They do not.**

Concern

- FE is trying to tell TOF what their probabilities ought to be for the numerator and the denominator of LR.
- Why not tell them what their posterior odds ought to be? That would be more rational and more coherent !! (and arguably more correct).
- Logic tells us that this whole paradigm of a FE telling the TOF how to think, **for part of the Bayes Rule equation, but not for ALL of the equation**, should concern us.
- Nothing wrong with Bayesian thinking or Bayes Rule. What seems strange is how we use it or propose to use it.

Three Questions

For what it is worth, let us suppose that we actually buy into the hybrid version of Bayes Rule. The focus then is on LR of FE rather than on LR of TOF.

Question 1

- **What is the parameter we are constructing an interval for when we present an interval for the value of evidence? (Or perhaps what additional information does an interval capture about the value of evidence?)**
- We are assigning a value to

$$LR = \frac{P[E|H_p]}{P[E|H_d]}.$$

  The additional information captured by the interval is that it communicates, more honestly, how well FE **knows** the value of their own LR.
- **Bottom line:** We make a whole **boat load of assumptions** to get our answer. How can we state that we know the answer without error?

Does "Model Validation" Solve the Problem?

- Claims to the effect that **we have validated our models** are often highly inadequate BECAUSE there are also other models that would pass all the validation tests conducted.
- Each model will lead to a different LR value.
- **Let us be honest**. Let us express how well we actually **know** the value of our OWN LR !! (Let alone the LR of TOF).

Use the BEST Available Method

- All proposed *LR*s are SCOREs that are generally good discriminators.
- Performance of discriminators may be compared using ROC curves (or other similar performance measures)
- Models with *comparable* performance may give different LRs in a particular application.
- Recognize this source of uncertainty.

Question 2

- **How does a decision maker use an interval to make a decision? (I would add in a logical an coherent manner.)**
- I am not sure if this is a fair question.
- If I were a forensic expert, I should tell the TOF what I know and what I can demonstrate. If I do not have precise results (because I have made assumptions to fill gaps in knowledge), it is my duty to reveal that.

Question 3

Does presenting the value of forensic evidence cause any harm?

- Depends on what you mean by **value** forensic evidence.
- If you mean a single LR assigned by the FE without giving a sense of other reasonable values one could have arrived at, then my answer would be YES.
- If you mean, present information that is demonstrable, then my answer is: I am at least communicating the information I actually have.
- If this is deemed unsatisfactory, then the criminal justice system should think of better approaches.
- **It does not mean** that the FE should present a single LR value using one out of many **equally plausible** assumption sets.

THANK YOU!

Still Friends?

I hope so.