Information Fusion (IFU), Summer Semester 2023

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Excercise 2: Basics on Information Fusion

This exercise takes a closer look into selected topics from the second lecture (L_IFU_2). Again it is supposed to help you self-check whether you comprehend the lecture. Please work through this exercise until **20.04.2023** and be prepared to talk about your ideas, examples, and opinions in the meeting.

2.1 Ignorance

Realising one's extent of ignorance is – philosophically speaking – a lifelong task. Having gained an understanding of uncertainties, we now seek to contextualize it within the broader framework of ignorance. Recognizing the root causes of our ignorance can help us choose the appropriate strategy to address it effectively.

Ayyub and Klir [1, p.53] put up the following taxonomy of ignorance[1]:

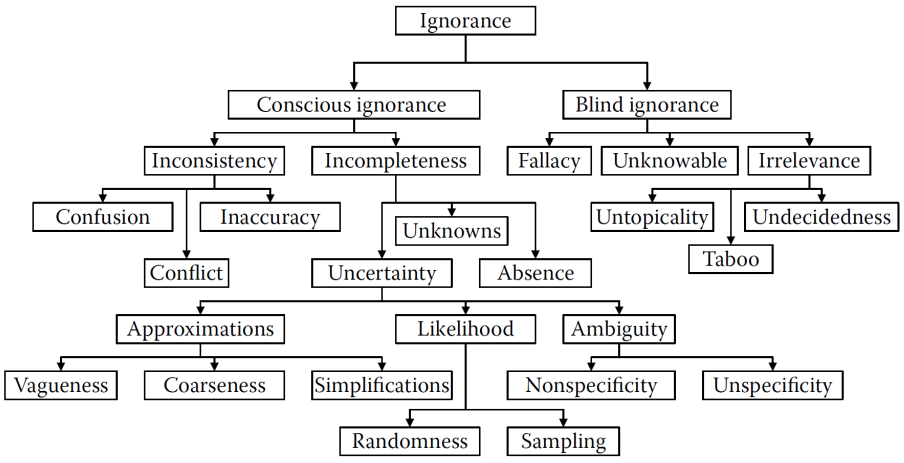

Figure 1: A taxonomy of ignorance given in [1, p.53].

- Do you agree with all subcategories of ignorance (placement, wording, ...)? Are there missing items?
- Point out the difference between ignorance and uncertainty.
- Assume you have a technical sensor and you take a single measurement. Does the measurement process provide complete knowledge about the measurand (see also L_IFU_1, slide 13) ? Which types of ignorance may this measurement be subject to? Is the situation different if you use multiple sensors measuring each?

[1] In general, their book is worth a read since they focus specifically on engineering applications – it is provided as additional material to this course.

2.2 Strategies for Information Integration

Durrant-Whyte has formulated different strategies for integrating information. These are

- *competitive*,
- *complementary*,
- and *cooperative*

integration [2, p. 88]. The lecture slides address the difference between these very briefly. Describe in your own words each strategy and its purpose. Elaborate on the difference between complementary and cooperative integration in particular. Elmenreich recapped important issues regarding information fusion in his paper – including the mentioned strategies [3, p. 8 ff.][2]. This may help in understanding the topic.

2.3 Dirty Secrets

When designing information fusion systems, there are several pitfalls. These pitfalls or dirty secrets are listed in the following. Some of these (3-6, 8, 9) are postulated by Hall and Steinberg in their paper [4]. These dirty secrets have been published in 2001 before the latest resurgence of artificial intelligence starting in ca. 2005 (the most recent AI spring). Read through the secrets (look into Hall and Steinberg's [4] or Lohweg and Mönks' paper [5]), describe the meaning of them in your own words, and give an opinion on whether they still hold – for fusion as well as for AI systems – today.

1. A fusion system designer has to understand the monitored system (e.g. production machine).
   And a data scientist has to understand the source of his data. But to which degree?
2. A human expert who can interpret measurement results is absolutely necessary.
   What happens if there are too much data to cover by a human expert?
3. There is no substitute for an excellent or at least a good sensor.
4. Downstream processing cannot absolve upstream sins.
5. Fusion may result in worse performance.
6. There is no such thing as a magic (fusion) algorithm.
   What requirements must be met for an algorithm to work. Are they always the same?
7. Data are never perfectly de-correlated.
   Is this always a problem? Tell strategies to overcome this limitation.
8. There will never be enough training data.
   Have you ever heard of the "Curse of Dimensionality"?
9. Fusion is not a static process.
   How can sensor drift impact the performance of information fusion systems?

[2] Elmenreich's paper summarises a lot of different basic aspects of information fusion including, e.g., definitions of fusion, goals, and architectures. It helps in getting a deeper understanding of the lecture's topic and is in general worth a read.

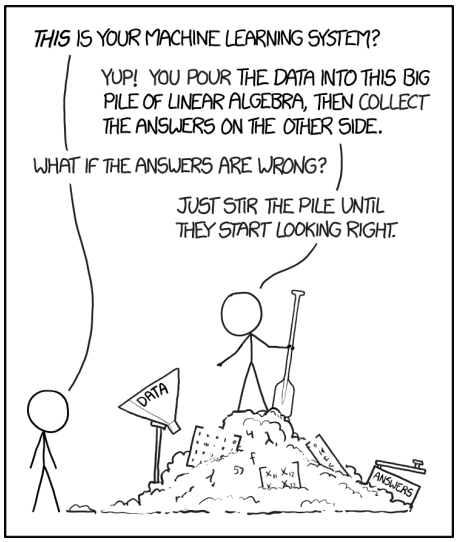

Figure 2: Relevant xkcd

References

[1] Bilal M. Ayyub and George Jiri Klir. *Uncertainty Modeling and Analysis in Engineering and the Sciences*. Chapman & Hall/CRC, Boca Raton, FL, 2006.

[2] H. F. Durrant-Whyte. Sensor Models and Multisensor Integration. *The International Journal of Robotics Research*, 7(6):97–113, 1988.

[3] Wilfried Elmenreich. An introduction to sensor fusion. Vienna, Austria, 2002.

[4] D. L. Hall and A. Steinberg. Dirty Secrets in Multisensor Data Fusion, 2001.

[5] Volker Lohweg and Uwe Mönks. Fuzzy-pattern-classifier based sensor fusion for machine conditioning. *Sensor Fusion and its Applications*, pages 319–346, 2010.