Kurt Weichselberger's Contribution to IP

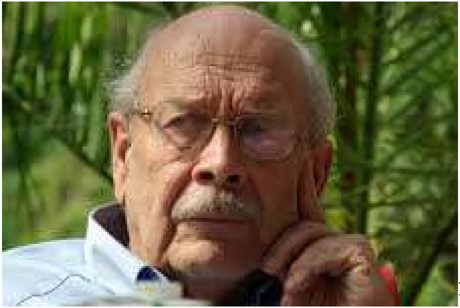
Thomas Augustin & Rudolf Seising

LMU Munich & FSU Jena

ISIPTA '17

Introduction and Overview

- Kurt Weichselberger passed away at 7th February last year
- He participated in the first six ISIPTAs, contributing papers, a tutorial and a special session
- **Look back at his work on IP**

[1]

[1] Photo kindly provided by Weichselberger's family

Introduction and Overview: The Project, Rudolf Seising

- Our work is embedded in a project studying the history of Statistics at LMU Munich
- Rudolf Seising:
  - History of Science
  - LMU and German Museum Munich, currently temporary professor in Jena
  - also expert in history of fuzzy sets, soft computing

Kurt Weichselberger: Biographical Sketch

- *April 13, 1929, in Vienna
- 1953 PhD (Dr. Phil), supervised by Johann Radon
- Dep. of Statistics in Vienna (W. Winkler's chair); social research institute in Dortmund; Cologne (J. Pfanzagls' chair)
- 1962 Habilitation with a thesis on controlling census results
- 1963–1969 chair in statistics, Technische Univ. Berlin
- 1967-68 university president (Rektor) TU Berlin
- from 1969 LMU Munich
- 1974 Foundation of the Institute of Statistics and Philosophy of Science at LMU
- from 1997 emeritus professor
- † February 7, 2016, in Grafing

Overview of the talk

1960

Social statistics; QC; TSAnal.

2 Logical prob. I (Wb, 1968)

?

1970

1980

1990

3 Probability intervals (Wb & Pöhlmann, 1990)

2000

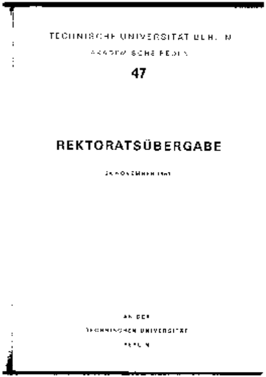
4 Elementare Grundbegriffe (Wb, 2001)

2010

5 Logical prob. II (Wb, 2005ff)

photo kindly provided by Weichselberger's family

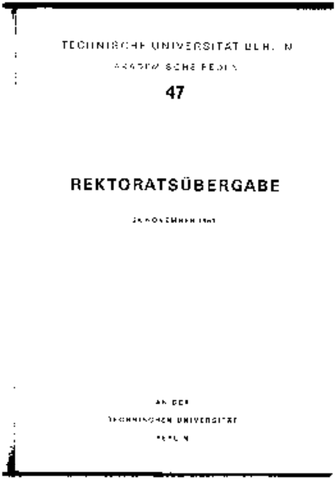
Table of contents



47

REKTORATSÜBERGABE

Inaugural Speech as Rector


47

REKTORATSÜBERGABE

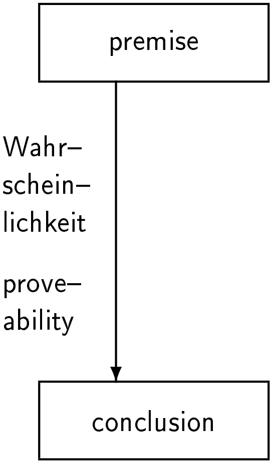
Der Rektor Professor Dr. phil. Kurt Weichselberger

Logical Probability: Background and Foundations I

- Background: Intensive discussion about Fisher's fiducial argument
- "[...] an attempt to eat the Bayesian omelette without breaking the Bayesian eggs" (Savage 1961, Proc 4th Berkeley)
- *"A comprehensive methodology of probabilistic modelling and statistical reasoning, which makes possible hierarchical modelling with information gained from empirical data.*
  To achieve the goals of Bayesian approach – but without the pre-requisite of an assumed prior probability."
  (Source: Special session ISIPTA '09, Durham (UK), p. 3)

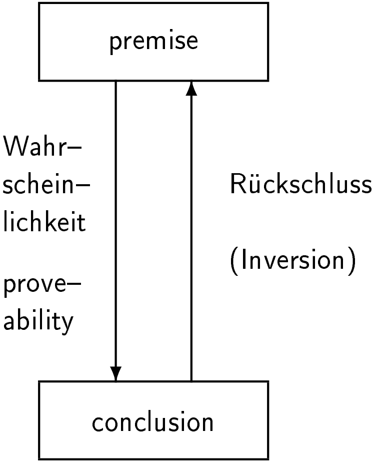
Logical Probability as a Two-Place Function

Two-place function: $P(\text{conclusion}||\text{premise})$



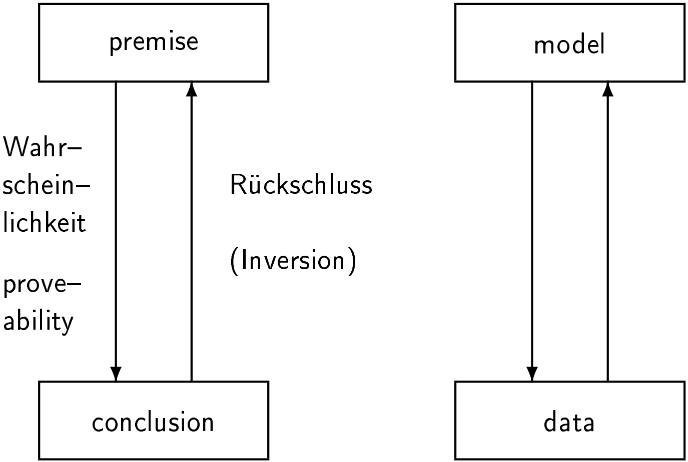
Logical Probability as a Two-Place Function

Two-place function: $P(\text{conclusion}||\text{premise})$



Logical Probability as a Two-Place Function

Two-place function: $P(\text{conclusion}\|\text{premise})$



Logical Probability: Inaugural Speech

[...W]e are challenged with the task to reconceptualise the foundations of probability. The question is whether we can make progress towards a broader concept designation without losing key benefits of the previous – objectivistic – concept.
[...] *As in many cases in the history of science it is shown also here that – as a form of compensation for desired benefits – we have to abandon a "habit of thinking" (*Denkgewohnheit*). In the present case this is the habit of thinking that the probability is always a number. We must instead allow sets of numbers – say the interval between 0.2 and 0.3 – to act as the probability of the inference from the proposition B to the proposition A. [...] This extension of the probability concept from a number to a set of numbers is encouraged as soon as we try to formalize Fisher's fiducial probability. Therefore, the American Henry Kyburg Jr. has already taken a similar approach [....]* (Weichselberger, 1968, p. 47) [translation from German by TA & RS]

Overview of the talk

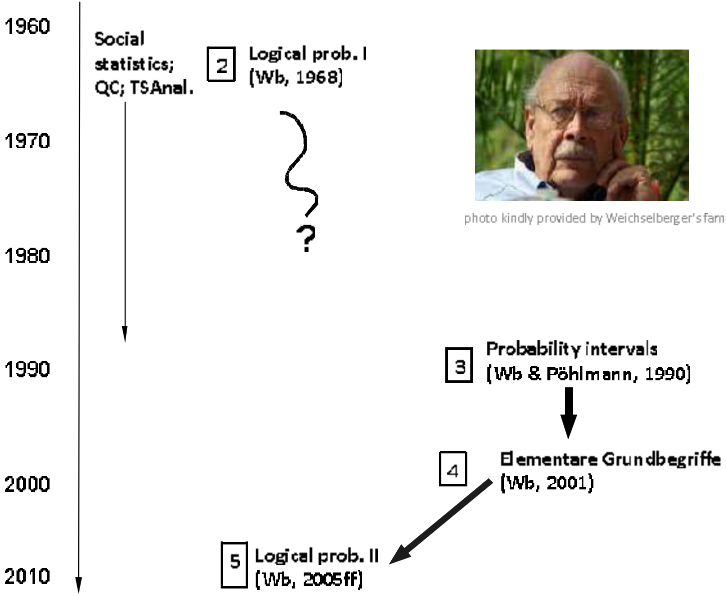


photo kindly provided by Weichselberger's family

Table of contents

Background

- Modelling uncertain knowledge
- expert systems !
- intensive discussion in computer science (AI)
- big challenge for statistical methodology: tradional probabilities demand an unrealistic high level of precision and internal consistency
- almost entirely ignored in statistics
- "flexible uncertainty calculi" (e.g. MYCIN: certainty factors)
- Dempster Shafer Theory, combination rule
- Fuzzy Sets

Develop a probabilistically sound, flexible uncertainty calculus

[...An] argument against a possible application of probability theory [, understood in its traditional, precise form here,] in diagnostic systems is as follows: While probability theory affords statements, using real numbers as measures of uncertainty, the informative background of diagnostic systems is often not strong enough to justify statements of this type. [. . .] ***However, it is possible to expand the framework of probability theory in order to meet these requirements without violating its fundamental assumptions.*** *[. . . W]e believe that the weakness of estimates for measures of uncertainty as used in diagnostic systems represents a stimulus to enrich probability theory and the methodological apparatus derived from it, rather than an excuse for avoiding its theoretical claims.* (Weichselberger and Pöhlmann, 1990, Springer LNAI, p. 2; emphasis by TA& RS)

Probability Intervals (PRIs): Weichselberger & Pöhlmann (1990, Springer LNAI)

- *One-place probability*: probability of events
- Sample space $\Omega = \{\omega_1, \omega_2 \ldots \omega_k\}$
- specify interval-valued assignments

$$[L(E_i), U(E_i)]$$

  on the singletons $E_i := \{\omega_i\}, i = 1 \ldots, k$, only
- *R-PRI:* reasonable ($\stackrel{\approx}{\longrightarrow}$ avoiding sure loss)
- *F-PRI:* feasable ($\stackrel{\approx}{\longrightarrow}$ coherent)
- *derived PRI:* ($\stackrel{\approx}{\longrightarrow}$ natural extension)

- "interval estimates" $\longrightarrow$ sensitivity analysis point of view

Table of contents

Elementare Grundbegriffe, Vol. 1 (2001): Contents I

1. Background and Historical Overview
2. Axioms
    - Measurable space $(\Omega, \mathcal{A})$, assignments on $\sigma-$ fields:

$$P(\cdot) = [L(\cdot), U(\cdot)]$$

    - Structure $\mathcal{M}$: set of all Kolmogorovian probabilities compatible with $P(\cdot)$
    - *R-probability*: $\mathcal{M} \neq \emptyset$ ($\stackrel{\approx}{\longrightarrow}$ avoiding sure loss)
    - *F-probability*: $L(\cdot)$ and $U(\cdot)$ are envelopes of $\mathcal{M}$ ($\stackrel{\approx}{\longrightarrow}$ coherence)

$$L(A) = \inf_{p(\cdot)\in\mathcal{M}} p(A) \quad \text{and} \quad U(A) = \sup_{p(\cdot)\in\mathcal{M}} p(A)\,, \quad \forall A \in \mathcal{A}\,.$$

    - From R-probability to F-probability
        - *rigorous standpoint* ($\stackrel{\approx}{\longrightarrow}$ natural extension)
        - *cautious standpoint* ($\stackrel{\approx}{\longrightarrow}$??)

Elementare Grundbegriffe, Vol. 1 (2001): Contents II

3 Partially determinate probability
- Assessments on $\mathcal{A}_L, \mathcal{A}_U \subseteq \mathcal{A}$
- *Normal completion* (→ natural extension)
- *Probability intervals*
- *Cumulative F-probability:*→ p-boxes

4 Finite Spaces
- Linear programming
  - Checking R- and F-probability
  - Calculation of natural extension and of the assignment resulting from the cautious standpoint.
  - Duality theory is also powerful for deriving theoretical results
- Generalized uniform probability/principle of insufficient reason
  - *Epistemic Symmetry*: No knowledge of asymmetry (negative symmetry)
  - *Physical Symmetry*: Knowledge of symmetry (positive symmetry)

Activities 1991 to 2003 (Preparing the Book and after it)

- Melchsee-Frutt workshop
  - Walley, Goldstein, Hampel, Coolen, Morgenthaler, Smets ...
- The first ISIPTAs
- Lev Utkin in Munich as Humboldt Fellow
- Colloquia on the occasions of 75th and 80th birthday

2

[2] photos kindly provided by Frank Coolen

Further Results on One-Place Probability

- manuscript of some 350 pages
- law of large numbers
- conditional probabilities: *intuitive* versus *canonical* concept
- Bayes' theorem
- parametric models: interval-valued parameters

Table of contents

Symmetrische Wahrscheinlichkeitstheorie

Kurt Weichselberger
in Zusammenarbeit mit
Anton Wallner

12. August 2009

Symmetrical Theory: Weichselberger (2009, V49, 268 pages)

I The Logical Concept of Probability

- W-fields: Axioms SI, SII
- Independence

II Duality

- concordant W-fields
- Axiom SIII
  perfect duality
- applications in the classical context

III Inference

- regression
- preliminary: concatenation of W-fields
- preliminary: quasi-concordance

Symmetrische
Wahrscheinlichkeitstheorie

Kurt Weichselberger
in Zusammenarbeit mit
Anton Wallner

12. August 2009

Table of contents

Concluding Remarks

- Still challenging research program
- Embed it into/combine with current developments

- Attempts to build up a memorial page !?
- Archive office and private estate

Overview of the talk

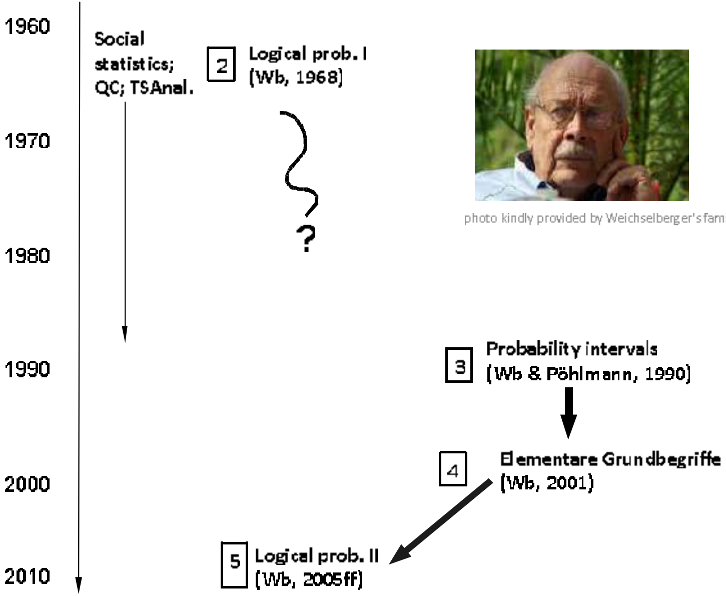


photo kindly provided by Weichselberger's family