C. F. Gauss: Theoria Combinationis Observationum Erroribus Minimis Obnoxiae. Pars Prior. Pars Posterior. Supplementum. Theory of the Combination of Observations Least Subject to Errors. Part One. Part Two. Supplement. Translated by G. W. Stewart. Classics in Applied Mathematics Series, Society for Industrial and Applied Mathematics, Philadelphia, 1995, ISBN 0-89871-347-1, XI/241 pp., $28.50

Reviewed by F. Pukelsheim, Augsburg

Calculus probabilitatis contra La Place defensus. This is Gauss's famous diary entry of 17 June 1798 that he later repeatedly quoted to defend his priority on the Method of Least Squares [14, Band X,1, p. 533]. The *Theoria Combinationis* contains Gauss's definite treatment of the subject. It also includes what in today's language is called Gaussian elimination and hence serves a seminal function for modern numerical linear algebra.

The translation under review is authored by G. W. Stewart, an outstanding member of the mathematical profession, and a successful author of various texts on matrix computations and numerical analysis. The triumvirate of SIAM, Classics, and Stewart raised great expectations, and I became instantly caught up in the enthusiasm that the book successfully conveys to the reader. I regret to say that much of my enthusiasm wore away as I read deeper into the project.

Aim

The Introduction defines the aims as follows (pp. x–xi):

> "The following work is a translation of the *Theoria Combinationis Observationum* as it appears in Gauss's collected works, as well as the accompanying German notices (*Anzeigen*). The translator of Gauss, or of any author writing in Latin, must make some difficult choices. [...] Our language has the resources to render Gauss almost word for word into grammatically correct sentences. But the result is painful to read and does no justice to Gauss's style, which is balanced and lucid, albeit cautious."
>
> "In this translation I have aimed for the learned technical prose of our time. The effect is as if an editor had taken a blue pencil to a literal translation of Gauss: sentences and paragraphs have been divided; adverbs and adverbial phrases have been pruned; elaborate turns of phrase have been tightened. But there is a limit to this process, and I have tried never to abandon Gauss's meaning for ease of expression."
>
> "The cost of all this is a loss of nuance, especially in tone, and historians who need to resolve fine points should consult the original, which accompanies the translation."

The Latin original and the English translation are arranged on facing pages, with *Pars Prior* covering pages 2–47, *Pars Posterior* pages 50–97, *Supplementum* pages 100–171. Pages 174–203 follow with a contraposition of the German abstracts and their English translations. Pages 207–235 contain a review-type Afterword by the translator. The book concludes with the References on pages 237–241.

In Gauss's original memoirs the sections are untitled. The list of Contents (pp. v–vii) provides titles for all 40 sections of the *Pars Prior* and *Pars Posterior*, and the 25 sections of the *Supplementum*. These titles are quite to the point and helpful, but not reproduced in the translation.

Sources

The source of "the original, which accompanies the translation" remains vague. Gauss's publications in the *Commentationes societatis regiae scientiarum Gottingensis recentiores* are listed as items [8, 9, 11] in the References. There it says that they are "cited and reprinted" in the *Werke* [14]. It is apparently the latter that served as the basis for the present translation.

However, by now there exist two editions of the *Werke*. Reference [14] evidently refers to the First Edition, for which it gives the publication years 1870–1928, but which actually appeared in the period 1863–1933. There is also a more recent Second Edition ⟨1⟩, and – more important – the *Commentationes* themselves are available as a reprint ⟨2⟩. These two additional sources are not mentioned in the book under review.

TEX

The "original" is not reproduced, but typeset afresh in TEX. The reset Latin text abounds with misprints. It starts with "observatinum" [observationum] in line 3 of the first page 2, and carries through to "ponders" [ponderis] in line 2 of the last page 170. There is an amiable Latin American bias: "negative" [negativa, p. 16], "positive" [positiva, p. 16], "plausible" [plausibiles, p. 54], "obtinemum" [obtinemus, p. 56], "Function" [Functio, p. 56], "complete" [completo, p. 68], "THEOREM" [THEOREMA, p. 74]. Etc. etc.

Using TEX both for the Latin original and the English translation entails the nice feature that the displayed formulas can be kept identical. Unfortunately, this strategy also keeps the misprints identical and deprives the reader of the possibility of easily checking for correctness: The factor $(1-\mu f)^2$ in the denominator of the last lines of pages 16–17 must read $(1-f)^2$; of the signs on pages 154–155 three are wrong, and on pages 156–157 one is wrong.

Faithfulness

The SIAM Classics version is not a reproduction of the Latin original, but an edited version of it. I get the impression that the intention is to make the original conform to the translation!

Gauss's table entry "0" (p. 156) is turned into "0.000". The number 22 877,94 now appears as 22,877.94 (p. 162). This may please the US American reader, but has no place in Gauss's "original" Latin text. Gauss indicated

units like a meter in the form 0^m1209, as was common in his times. SIAM Classics converts this into 0.1209 m (p. 168). Gauss runs no risk of confounding the unit "m" with the variable "*m*" that is also occurring in the context; the present text does.

There are faults that go beyond notational intricacies. Page 19 features Footnote 5:

> "The text reads *pro valore ipsius λ minor quam* $\sqrt{\frac{4}{3}}$, an obvious misprint."

Although correct, the footnote is inappropriate. The SIAM text reads "minor," as does the First Edition of the *Werke* [14, Band IV, p. 11]. This is "an obvious misprint," since in Gauss's original paper in the *Commentationes* ⟨2⟩ it reads "maiori," and the Second Edition of the *Werke* ⟨1⟩ corrects the error in the First Edition and has "maiore." The metamorphosis from "maiori" to "minor" to "maiore" to "minor" has its charm, except it exposes all too openly the lack of text critical research underlying the present work.

In the *Anzeige* of the *Pars Prior*, Gauss mentions two useful inequalities for the mean error. The SIAM text, in Footnote 13 (p. 185), rightly points out that the fraction $\sqrt{\frac{3}{4}}$ must be corrected to read $\sqrt{\frac{4}{3}}$. Then it continues:

> "However, even with this correction, the first inequality does not follow from the theorem stated in Part One."

The cross-reference to "the theorem stated in Part One" is not made precise, and the reader is left to contemplate the implications of Footnote 13. Fortunately, there is nothing to it. Gauss's wording in the penultimate sentence of the *Anzeige* connects to the last two sentences of Section 10 in Part One. There Gauss writes (p. 18): "*Porro facile e theoremate nostro concluditur*" [Furthermore it is easily concluded from our theorem]. In fact, Gauss's "It is easy to see" overrules the "It does not follow" of Footnote 13. In my 1994 note ⟨4⟩ I took the liberty of quoting Gauss's encouraging hint that the final result "is easily concluded" from an earlier one. The lines that then follow are my public confession that what is "facile concluditur" on the scale of a Princeps Mathematicorum may be worth about six lines of argument on the scale of a humble epigone.

Die Würde der Wissenschaft

One of the main results of the *Pars Posterior* that Gauss is anxious to advertise in the *Anzeige* is that when the variance is estimated by the sum of squares, the correct factor is $\frac{1}{n-k}$, where n is the sample size and k is the number of parameters for the mean. Gauss concedes that with the commonly used factor $\frac{1}{n}$ the bias becomes negligible for large sample sizes n. But even so, he continues, "*erfordert die Würde der Wissenschaft*" (p. 192) use of the correct factor. Gauss's authoritative "dignity of science" is the subject that reigns the phrase. The translation degrades it to a pale adverbial clause, dangling between commas (p. 193):

> "But even so, in the name of science, we should determine completely and definitively the amount of error."

In class I used to present the variance estimate with factor $\frac{1}{n-k}$ under the heading of unbiasedness. Then O. Sheynin alerted me to his paper listed as reference [38] in the book under review and its paragraph [38, p. 37] pointing to the "Würde der Wissenschaft." Ever since then I teach the result under the heading of *Gauss's Theorem on the Dignity of Science*, with the rewarding effect that the students' interest and attention are guaranteed. With the present translation, I doubt I would have ever come close to thinking about this.

Opinion

I feel the present book represents a failure for SIAM in its function as the publisher. Nowadays the physical act of publication is easy, but proper editorial care and publishing expertise are still needed. Can a society provide it? I would claim SIAM has not in this instance.

Research into the works of our masters is almost always fascinating and at times constitutes a *Lesevergnügen eines Mathematikers* ⟨3⟩. The intention of making classical texts readily available, as originals and in translation, must of course be highly welcomed. Clearly the book under review is such a labor of love, intended to help spreading Gauss's work. There are long passages where the original Latin text of Gauss's memoirs is reproduced correctly, and where the English translation is very good.

The shortcomings that I criticized in this review may be negligible in the eyes of many who will want to buy the book. And scholars are anyway well advised to never put much trust in a retypeset text, but research the original. In this sense the inconsistencies, if not mistaken as an offense, may serve as a stimulus to inquire into what Gauss really wrote and meant. Then, at the end of the study, the reader may add another entry into his or her diary: *Opera Gaussii contra SIAM defensa.*

References

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⟨3⟩ Lüneburg H (1993) Leonardi Pisani Liber Abbaci oder Lesevergnügen eines Mathematikers. BI-Wissenschaftsverlag, Mannheim

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Book Reviews

Contents

E. B. Andersen: Introduction to the Statistical Analysis of Categorical Data, Springer-Verlag, Berlin, Heidelberg, 1997, XI/265 pp., DM 59.00, öS 430.70, sFr 52.00

Reviewed by A. Agresti, Gainesville

This text, by one of the world's most accomplished researchers in statistical theory and methodology for discrete data, is a shorter (263 pp. vs. 532 pp.) version of Andersen (1990), having much the same style and emphasis. The preface does not specify the intended audience, but most of the book seems directed to applied statisticians or researchers interested in using the methods discussed.

After a brief introduction, Chapter 2 on Basic Theory deals with some elegant results of exponential family theory and their application to binomial, Poisson, and multinomial distributions and loglinear models for those dis-