

the method of least squares can converge much more quickly. This is because the function to be minimized is of form

$$F(x) = \sum_{k=1}^m \{f_k(x)\}^2$$

so it can be reasonable to assume that

$$\frac{\partial^2}{\partial x_i \partial x_j} F(x) = 2 \sum_{k=1}^m \frac{\partial f_k}{\partial x_i} \cdot \frac{\partial f_k}{\partial x_j}.$$

Therefore an evaluation of all the derivatives at a single point is sufficient to predict the position of the minimum. It is likely that a method for minimizing a sum of squares without using derivatives will be developed, and one would expect it to be faster than the method of this paper by a factor of order n . Of course, all of these

procedures may find a local minimum rather than the absolute minimum, and this is a difficult problem to overcome. If there are many variables it will certainly prove too arduous to apply a searching technique, so it is recommended that different initial approximations are tried to see if they cause more favourable extrema to be found.

12. Acknowledgements

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References

- DAVIDON, W. C. (1959). "Variable metric method for minimization," A.E.C. Research and Development Report, ANL-5990 (Rev.).
- FLETCHER, R., and POWELL, M. J. D. (1963). "A rapidly convergent descent method for minimization," *The Computer Journal*, Vol. 6, p. 163.
- HIMSWORTH, F. R., SPENDLEY, W., and HEXT, G. R. (1962). "The sequential application of simplex designs in optimisation and evolutionary operation," *Technometrics*, Vol. 4, p. 441.
- POWELL, M. J. D. (1962). "An iterative method for finding stationary values of a function of several variables," *The Computer Journal*, Vol. 5, p. 147.
- SMITH, C. S. (1962). "The automatic computation of maximum likelihood estimates," N.C.B. Scientific Dept., Report No. S.C. 846/MR/40.
- SPANG, H. A. (1962). "A review of minimization techniques for nonlinear functions," *S.I.A.M. Review*, Vol. 4, p. 343.
- ROSENBRICK, H. H. (1960). "An automatic method for finding the greatest or least value of a function," *The Computer Journal*, Vol. 3, p. 175.

Errata to Errata

"Elementary Divisors of the Liebmann Process," by G. A. Miles, K. L. Stewart and G. J. Tee. *The Computer Journal*, Vol. 6, No. 4, pp. 352-355 (January, 1964).

We regret that misprints occurred in the Errata to this article, published in *The Computer Journal*, Vol. 7, No. 1, p. 39 (April 1964). These previous Errata should be replaced by the following corrections to the original article:

- (1) P. 353, line before (2.12), replace " m_i " by " λ^{m_i} ".
- (2) P. 354, third line after (3.13), replace " $\frac{1}{2}(n - m)$ " by " $\eta^{\frac{1}{2}(n - m)}$ ".
- (3) P. 355, in (3.18), replace " $\eta^{1/2(n - m + v + a)}$ " by " $\eta^{\frac{1}{2}(n - m + v + a)}$ ".