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Novel Methods for Maximizing and Evaluating Adaptive Measurement Efficiency

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Final Report for Period: 07/1998 - 05/2002   **Submitted on:** 02/12/2004
Principal Investigator: Cobo-Lewis, Alan B.   **Award ID:** 9896277
Organization: University of Maine
Title:
Novel Methods for Maximizing and Evaluating Adaptive   Measurement Efficiency

Project Participants

Senior Personnel
    Name: Cobo-Lewis, Alan
    Worked for more than 160 Hours: Yes
    Contribution to Project:

Post-doc

Graduate Student
    Name: Yan, Liying
    Worked for more than 160 Hours: Yes
    Contribution to Project:
    Ms Yang was a graduate student in computer science, and she programmed some of the simulations required for development of multivariate adaptive estimation.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates
    Name: Smallwood, Tasha
    Worked for more than 160 Hours: Yes
    Contribution to Project:

        Years of schooling completed: Junior
        Home Institution: Same as Research Site
        Home Institution if Other:
        Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
        Fiscal year(s) REU Participant supported: 2001
        REU Funding: REU supplement
    Name: Than, Lara
    Worked for more than 160 Hours: Yes
    Contribution to Project:

        Years of schooling completed: Sophomore
        Home Institution: Same as Research Site
        Home Institution if Other:
        Home Institution Highest Degree Granted(in fields supported by NSF): Associate's Degree
        Fiscal year(s) REU Participant supported:

REU Funding: REU supplement
Name: Montanti, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Associate's Degree
Fiscal year(s) REU Participant supported:
REU Funding: REU supplement

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

1. Simulations were conducted for estimating a categorical variable in the presence of nuisance variables.
2. Simulations were conducted for nonparametric adaptive estimation using randomly interleaved experiments ('interleaved staircases' in psychophysical parlance).
3. Theoretical investigations were conducted to elucidate the bias that has been shown to arise in some nonparametric adaptive estimation in psychophysical experiments.
4. Simulations were conducted for multivariate parametric adaptive estimation.
5. The PI explored the use of parameterization-invariant design.

Findings:

1. Adaptive Bayesian estimation of a categorical variable was feasible and more efficient than a heuristic alternative. It was also more robust with respect to violations of its assumptions (mismatch between assumed and actual subject characteristics).
2. It can be substantially suboptimal to follow the conventional practice in 2-alternative forced-choice designs of randomly interleaving two staircases, with starting above threshold and one below.
3. Where guessing rates and lapsing rates are low (e.g., in yes/no procedures with attentive subjects), common adaptive staircase procedures are essentially unbiased. Where guessing rates are subsantially higher than lapsing rates, skew is introduced in the stationary distribution of staircase position that introduces substantial bias in estimation of threshold. Yes/no paradigms and n-alternative forced-choice paradigms with n large substantially alleviate this bias.
4. Multivariate parametric adaptive estimation is feasible.
5. Parameterization-invariance design is feasible.

Training and Development:

The graduate research assistant acquired a great deal of practical experience with statistical and mathematical concepts. She also learned how to use object-oriented programming concepts to develop code for n-dimensional geometric objects that laid bare the analogies with more familiar 2-dimensional geometry.

Outreach Activities:

Journal Publications

Cobo-Lewis, A. B., "An adaptive psychophysical method for estimation of categorical variables", Perception and Psychophysics, p. 989, vol. 59, (1997). Published

Cobo-Lewis, A. B., "The source of bias in adaptive staircase procedures", Psychological Methods, p. , vol. , (   ). submitted and reviewed.

Cobo-Lewis, A. B., "Portfolio analyses of threshold-seeking procedures [Abstract of conference presentation]", Journal of Mathematical Psychology, p. 496, vol. 42, (1998). Published

Books or Other One-time Publications

Cobo-Lewis, A. B., & Eilers, R. E., "Auditory assessment", (2001). book chapter, Published
Editor(s): Singer, L. T., Zeskind, P. S.
Collection: Biobehavioral assessment of the infant
Bibliography: New York: Guilford. ISBN 1572306696

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

The findings have improved the efficiency of adaptive measurement in psychophysics, in experimental paradigms where individual trials are often information-poor and experiments are consequently long. The Bayesian adaptive methodology improves the information throughput in such experiments and improves on heuristic methods. The multivariate estimation also extends the utility of Bayesian adaptive estimation into realms where it is even more important because of the 'curse of dimensionality' (where the size of parameter space is exponential in the number of parameters). In addition, the work on nonparametric adaptive methods has helped reveal the source of bias in simpler adaptive methodology that has often incorrectly been taken to be safe because of its apparent lack of statistical assumptions. By revealint the source of such bias, it offers solutions for minimizing the bias.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

The research offered experience and training in practical scientific programming to a graduate student in a more theoretical computer science program.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

The methodology has been extended to another regime, as the original proposal suggested was feasible. Specifically, the basic research funded by this NSF grant served as a springboard from which the research program continued on to additional SBIR funding from NIH for the development of a computerized adaptive test of early language development in human infants and toddlers. This is currently resulting in commercialization of basic research growing out of the research seeded by the original NSF funding. Current contract negotiations indicate that the resulting software will be in press with a publisher of evaluation tools before the end of 2004. The practical societal benefit is to aid in the early identification and tracking of children with language delay, with the understanding that early identification and treatment leads to more effective treatment and substantial cost-savings over the lifetime of identified children. Although the SBIR research protocol was distinct from the research conducted under the NSF grant, it would not have been possible without NSF's funding of the earlier research.

Categories for which nothing is reported:

Organizational Partners

Activities and Findings: Any Outreach Activities

Any Web/Internet Site

Any Product

Contributions: To Any Other Disciplines

Contributions: To Any Resources for Research and Education