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WHY USE AUTOMATED STATISTICAL ALGORITHMS IN POLYGRAPH DATA ANALYSIS

Raymond Nelson

Automated statistical algorithms for psychophysiological detection of deception (PDD) and test data analysis (TDA) have been in development since the early 1980s and have been commercially available since the 1990s. Both proprietary and open source statistical methods have been accessible for over two decades. Increasing the adoption and use of these automated algorithms for PDD test data analysis offers numerous benefits, primarily by leveraging more robust statistical methods compared to manual scoring.

The practical advantages that automated computer algorithms provide to PDD field practitioners and PDD programs include potential enhancements in objectivity, reliability, reproducibility, accuracy, efficiency, and scalability. Automated algorithms mitigate human bias, reduce the likelihood of errors, and ensure consistency across different practitioners and testing scenarios.

Utilizing Advanced Statistical Methods

The field of statistics and data analysis has advanced considerably with the advent and availability of powerful and inexpensive microcomputers. Prior to this technological progress, calculations were often performed using paper and pencil methods, and the choice of statistical technique was frequently influenced by the computational burden. A review of historical research reports and publications reveals a predominant use of methods such as chi-squared tests and Mann-Whitney U tests. These methods, while somewhat limited, were manageable with manual computation.

In recent decades, however, the landscape of statistical analysis has evolved substantially. There has been a notable increase in the use of generalized linear models, multivariate analysis, multiple regression, Bayesian methods, and model fitting. Additionally, a variety of resampling

and simulation methods have become prevalent, along with ensemble methods that combine outputs from multiple algorithms. Machine learning techniques, which have the potential to improve over time by learning from new data, are also increasingly utilized.

Automation of statistical methods is now ubiquitous across various domains of data analysis, science, and testing, including psychophysiological detection of deception (PDD) testing. These advancements have facilitated more sophisticated and accurate analyses, enabling researchers and practitioners to handle complex data sets and draw more reliable conclusions.

Enhancing Objectivity and Reducing Subjective Bias

Automated statistical algorithms provide a highly standardized and evidence-based approach to data analysis, ensuring consistent feature extraction and analytic methodology across all tests and repeated analyses. Developers of these algorithms aim to optimize desired effect sizes – such as sensitivity, specificity, false positives, and false negatives – through rigorous reliance on evidence-based solutions. Automation can reduce the potential for human error and subjective bias, helping to achieve goals involving standardization and quality control, regardless of the complexity of the statistical procedures and workflow.

Implementing automated algorithms, whether fully or partially automated, can enhance the scientific rigor of PDD testing within the polygraph profession. This rigor is recognized by the public,

media, academic circles, legislative bodies, and the judicial and legal communities. Polygraph programs that prioritize standardization and reliability, such as those involved in high volume and high value security screening, can benefit from the ability to evaluate all PDD exams using the exact same parameters and procedures.

Improving Reliability and Accuracy

Automated data analysis algorithms can enhance the reliability and accuracy of PDD testing. Computer algorithms can efficiently employ advanced mathematical and procedural solutions for feature extraction, artifact rejection, pattern recognition, and quality assurance tasks. They can leverage analytic methods that provide greater statistical power with automated reliability, reducing vulnerability to subjective bias, imprinted experience, and unplanned reliance on untested hypotheses.

In contrast, achieving high reliability with manual scoring methods partially depends on procedures that can be reliably executed by field practitioners, who may have limited enthusiasm for complex mathematical and statistical calculations. Automated algorithms allow for the use of powerful analytical solutions while maintaining high reliability, contributing to more precise statistical confidence intervals for various test accuracy metrics, including sensitivity, specificity, false positive, and false negative rates. These core metrics form the basis for other statistical classifiers such as positive and negative predictive values, likelihood ratios, and posterior odds.



Compared to manual scoring, computer algorithms are less susceptible to unstandardized activities that could lead to reliance on unsupported assumptions or untested hypotheses. Automation can be thought of as a form of standardization and ensures more consistent and empirically supported results.

Efficiency and Scalability

TDA activities encompass several critical functions, including the inspection of multiple time-series recordings, assessment of numerous physiological signals, execution of complex procedures, and calculation of numerical and statistical classifiers. While manual scoring procedures are labor-intensive and time-consuming, involving both examiners and reviewers, computer algorithms can process data quickly and efficiently, regardless of the complexity of the analytic methods.

Automated TDA algorithms can scale to handle large data sets, reducing or eliminating the influence of skill variation, fatigue, and practice effects inherent to manual scoring methods. Program administrators may find that computer algorithms can increase efficiency of quality assurance tasks. In addition, researchers seeking new insights into the nuances and complexities of PDD test data can benefit from the efficiency of computer automation and the reduction of uncontrolled variation in their analyses. Program evaluation activities, which may involve large datasets of PDD exams, can be managed more effectively using automated methods.

A common criticism of PDD testing is the potential for false positives and false negatives, an issue inherent to all forms of scientific testing. This is due to the reliance on proxy signals, probability theory, and statistical methods to quantify phenomena that cannot be directly measured. Although often framed in unrealistic terms, the core of this criticism is that PDD testing is perceived as unreliable and overly subjective.

Computer algorithms address these concerns by automating procedures, calculating statistical classifiers, and quantifying the margin of uncertainty associated with each test result. This approach allows for the selection of procedures and decision thresholds that maximize desired effect sizes and minimize the potential for error. Automated computer algorithms can enhance the reliability and credibility of polygraph testing by providing a more objective and scientifically rigorous probabilistic framework that aligns PDD testing with other areas of science and forensics, where understanding the degree of uncertainty is as important as the conclusion itself.

The Role of Technology in Enhancing the Science of PDD Testing

The integration of automated statistical algorithms into PDD testing reflects a broader trend toward adopting technology in scientific, forensic, and security practices. Advances in computing power, data analytics, and machine learning have enabled the development of sophisticated tools that enhance the accuracy and reliability of PDD testing. For instance, machine learning models can be trained on large data sets to identify patterns and



correlations that might not be apparent through manual analysis. These models can continually improve as they are exposed to more data, becoming increasingly effective over time.

In PDD testing, deception and truth telling are regarded as probabilistic classifications. Various physiological indicators are extracted from the time-series recordings and transformed into dimensionless values, which can be combined to formulate an optimal statistical model or classifier. Advanced statistical techniques, such as Bayesian inference, have become substantially more accessible with the advent of powerful and inexpensive computers, allowing for a more comprehensive analysis of PDD data. This approach provides PDD field examiners, program administrators, and referring agents with a deeper and more practical understanding of test results, enabling them to make informed decisions based on probability estimates rather than binary judgments influenced by subjective intuition or gut feelings.

Ethical Considerations

The development and adoption of automated statistical algorithms for PDD data analysis must address several ethical considerations. Transparency and accountability are important for maintaining public trust and confidence when using technologies that influence human outcomes and futures. Expectations and requirements for transparency, accountability, reproducibility, and replication are necessary to ensure that computer algorithms perform as expected and to understand the potential for classification error. Interestingly, compared to the automated

reliability of computer algorithms, documenting and accounting for subjective visual/manual data analysis, for which human execution is variable both within and between individuals, is inherently difficult.

A key aspect of transparency is providing clear and complete documentation of the algorithms used, including their underlying principles and the data they are based on. This documentation should be accessible to examiners, scientists, and stakeholders. The objectives of such documentation are to enable the replication of analytic results, ensure the reproducibility of solutions with other datasets, and promote understanding of how test results are generated and interpreted. Expectations for documentation and accountability should extend to both manual and automated TDA methods.

Beyond transparency, the ethical implications of relying on advanced technology when making decisions about human individuals must be carefully considered. PDD test outcomes can have profound consequences on an individual's future, affecting their legal status, employment opportunities, and personal reputation. Therefore, it is important to establish ethical guidelines for the use of all PDD analytic methodologies, both automated and manual. These guidelines should address issues such as the rights of individual subjects and the necessity and degree of human oversight when using automated TDA solutions. The central fact that human professionals are ultimately responsible for their conclusions and decisions does not negate the ethical obligation to select the best available technology. Failure to utilize the best



available technology may eventually be used against professionals themselves, as it reflects a lack of due diligence and adherence to the highest standards of practice.

Understanding algorithmic bias is another ethical consideration. All data analysis methods are subject to potential bias, whether manual or automated. However, unlike manual TDA methods, which are inherently subjective and prone to covert or undocumented forms of bias, automated algorithm bias is more reliable and can therefore be more easily identified and mitigated.

Continuous monitoring and updating of automated algorithms is also an ethical consideration, especially when relying on machine learning methods that evolve with new data. Changes to algorithmic models, which may occur in response to outcomes and advancements in technology and data science, should be subject to ethical requirements for accountability and documentation. Importantly, changes and evolution in automated TDA methods may be more easily predicted and understood than in manual scoring methods, which are potentially subject to practitioner and administrative influence informed by imprinted experience or belief rather than data analysis.

Ethical frameworks should emphasize the importance of informed consent, ensuring that individuals undergoing PDD testing are aware of their rights and provided with accurate information about the capabilities and limitations of PDD testing – including whether data analysis is based on subjective or objective methods. Individuals should also be informed

if their data will be used in research datasets for the development and advancement of PDD models and methods. In addition, privacy and data security must be prioritized to protect sensitive information from unauthorized access and misuse. The potential misuse of data, whether intentional or accidental, should be addressed through strict data governance policies.

Many ethical considerations are not limited to the use of computers and automation, but also pertain to manual testing and data analytic methods.

Future Directions and Opportunities

The future of PDD testing depends on the continued development and refinement of computerized solutions, including statistical algorithms for TDA. Ongoing research and development efforts are essential to advancing the reliability and accuracy of PDD methods. Without leveraging the capabilities of advanced data analytic solutions, it is unlikely that current performance metrics will be surpassed. Neglecting or forgoing technology adoption may invite eventual disruption in the PDD profession.

One potential area of research is the application of deep learning techniques to PDD data. Deep learning models are capable of processing high-dimensional and complex data with great effectiveness. While manual PDD scoring methods have emphasized visual feature extraction as a separate process for each recording sensor, with subjective discussions about the influence or covariance between sensors, a high-dimensional approach to PDD data treats each recording sensor as a data



dimension. This includes upper and lower respiratory sensors, cardiovascular activity sensors, electrodermal activity sensors, and the optional vasomotor sensor. Interactions or covariance between each of the recording sensors can be regarded as additional data dimensions, each of which can be subject to objective methods and analysis. Furthermore, some of these sensors themselves have multiple dimensions. For instance, respiratory data encompass respiration rate, tidal volume, and residual volume. Cardiovascular data include pulse rate, cardiac stroke volume, and changes in arterial pressure. Electrodermal activity comprises both tonic and phasic information.

While deep learning algorithms can effectively process data sets with hundreds of dimensions, human performance in visual/intuitive (non-mathematical) data analysis is limited to working effectively with only a few dimensions – two or three at most for many individuals. However, effectively using high-dimensional data becomes computationally intensive, and the analytic methods grow exponentially complex. It is only through reliance on advanced techniques and computerized analysis methods that researchers and field practitioners can handle the intricacies of PDD data analysis with greater precision than is currently possible.

Another important area of research is the exploration of new physiological indicators that can be incorporated into PDD testing. Advances in sensor technology and physiological research may lead to the development or discovery of new indicators that are more reliable and less susceptible to manipulation. It is unlikely that new PDD sensors will provide

the same visual simplicity as traditional autonomic PDD sensors, which were developed when sensory observation and analysis were primary methods. New sensors are likely to make use of complex and subtle functions (e.g., central nervous system, vasomotor, oculomotor) that may lend themselves less easily to time-series data plots but can be effectively analyzed numerically within high-dimensional models.

Advancements in technology and methodology will not only improve the accuracy and reliability of PDD testing but also contribute to the broader acceptance and trust in polygraph results among stakeholders, including legal, forensic, and scientific communities. Neglecting advancements in technology, including the use of computer algorithms, increases the risk that traditional PDD solutions that remain primarily reliant on visual feature extraction and paper-and-pencil analytic methods may eventually be viewed as a form of anachronism.

Conclusion

The adoption of computer algorithms in polygraph data analysis enhances objectivity, accuracy, and efficiency, often surpassing the accuracy rates of human experts. By leveraging advanced statistical techniques and modern technology, polygraph data analysis can become more standardized, reliable, and scalable, addressing the limitations of manual scoring. Researchers aiming to advance the science of PDD testing will find it challenging to outperform current reliability and accuracy metrics using traditional or semi-subjective visual and manual scoring methods. As the polygraph profession



continues to evolve, embracing technological advancements will be essential for maintaining the scientific credibility and practical utility of PDD testing.

Traditional PDD scoring procedures have relied on visual feature extraction and paper-and-pencil calculations with integer scores and cutscores. Probabilistic discussions were limited to descriptions of observed performance with research or reference samples and did not provide information about the strength of support for conclusions about individual test results. This absence of more complete probabilistic discussion contributed to a context where strategic overconfidence – a belief in the infallibility or near-infallibility of PDD techniques based on examiner expertise – was a tempting yet ultimately problematic stance. Overconfidence may be marketable in the short term but leads to confusion and frustration when real-world observations fail to meet unrealistic expectations for perfection.

A scientific approach to PDD treats deception and truth-telling as probabilistic classifications. Physiological indicators are extracted from recorded data and combined mathematically and statistically to formulate an optimal statistical model or classifier. This approach allows

researchers and PDD practitioners to make informed decisions based on probability estimates rather than binary judgments influenced by subjective intuition or gut feelings. An evidence-based approach requires retaining methods that produce outcomes consistent with reasonable expectations and abandoning unsupported methods. Reliance on reproducible analytic methods enables the output of both categorical test results and statistical classifiers that describe the probabilistic strength of the information obtained from each test subject, alongside the computation of generalized effect sizes based on reference groups. Importantly, attempts to provide reproducible probabilistic and statistical analysis without employing modern computational capabilities are often impractical today.

In summary, while automated statistical algorithms provide numerous benefits for the accuracy and efficiency of polygraph testing, their implementation must be accompanied by robust ethical standards and transparency measures. This approach will help ensure that the technology is used responsibly, safeguarding the rights and dignity of individuals, while advancing the capabilities of PDD field practitioners and PDD programs.

