Practical Polygraph: Integration of Automation, Algorithms, and Artificial Intelligence with Human Expertise in 21st Century Polygraph Systems

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Algorithms are everywhere, and are not limited to polygraph test data analysis. At their most basic level, an algorithm is merely a set of data together with a procedure to produce a result such as accomplishing a goal or answering a question. Algorithms can provide for the automation of complex procedures, and can also be used to study and select the optimal solution from an array of possible solutions. The most powerful algorithms today can, for themselves, both articulate an array of possible solutions – akin to hypotheses testing and the generation of possible hypotheses for testing – and also evaluate the array of hypothesis. These methods are, at their core, based on statistical learning theory, but are often referred to using more dramatic and entertaining terms such as "machine learning" (ML) and "artificial intelligence" (AI).

AI refers to the ability of computers (algorithms) to work in a quasi-creative manner that can include the execution of procedures while also seemingly asking the array of scientific questions for which answers are being sought. (In contrast, older methods involved human experts who did the work of formulating scientific questions, then obtaining data and completing the analysis – increasingly with the use of analytic software.) Of course, algorithms and AI are still not actually creative or intelligent, and most algorithms today have been programmed or instructed to ask and answer only certain types of questions based on available input data.

Input data today has become quite large, and the range of possible questions has become so large, and complexity of problem solving methods have become so sophisticated, that humans sometimes discuss the parallels and differences between the computer (algorithm) capabilities and the ways that humans think and solve problems. These discussions can be expansive to the degree that humans, including humans who are experts in science and philosophy, are sometimes engaged in interesting arguments about what it means to "think," what it means tobe sentient or self aware, and even what it means to be alive. At this time, however,any actual intelligence in AI is still artificial and the consensus is still that even the most powerful algorithms are neitheralive nor able to actually think. They are still largely viewed as not actually creative, and remain non-sentient. Nor dothey possess a system of emotions orvalues. Regardless of how sophisticated, algorithms are merely processes designed to achieve a goal with some available data.

Internet search engines, social media, news feeds, auto-pilot systems in aviation, and even our emojis (my new iPhone canuse its camera to adjust an emoji based on my facial expression) all make use of algorithms of varying levels of complexity. LASIK and other microsurgical procedures will use computers to calculate, and even execute, an optimal solution. LiDAR and other 3D scanning methods, along with the ability to calculate complexequations easily, have forever changed engineering, including architecture and design. And 3D printing has transformed product development, prototyping and production. Even the military today makes use of computer guided munitions and computer generated fire control solutions (though, for reasons that should be obvious, they will also maintain their capabilities for manual computations). New cars today seem to increasingly make use of complex algorithms to regulate the fuel mixture (or battery levels) for the weather, driving conditions and desired output or performance. Most new cars today will have adaptive cruise control (a very simple system of "intelligence") to maintain a safe desired distance from the vehicle in front of us. Assisted-steering or lane-assist technology is increasingly common. This later technology may, in my view, contribute to more texting while driving – and this brings us to our present need for a thoughtful and coherent conceptual pathway for how we may want to think about any plan for the implementation and use of automated or autonomous systems inthe context of human professional activities and human decision making, including polygraphic credibility assessment testing (i.e., lie "detection").

The polygraph profession, along with the rest of the world, is presently undergoingand observing the rapid implementation of increasingly powerful new computing technologies. It is happening everywhere. We are participating in it even if we preferto try to think we are not. During recent weeks, hardly a day has gone by in whichwe did not read or hear about some new form of generative AI that can produce visual images, write college research papers, check college research papers for plagiarism (or algorithm content), or even write and debug computer code. But fundamentally, and for many reasons, we can expect to remain committed to the notion that the human experts should remain responsible for most decisions – especially when our decisions affect the future well-being and rights of other humans. The alternative to this would be a world in which humans are not responsible, and in which machines and robots may begin to make important decisions that affect the future well-being and rights of humans. Science fiction movies have pondered and explored the possibilities here with sufficient redundancy that, although we may not have a simple and concise solution, ethicists and scientists are at least paying attention to the potential hazards.

At the core of all this is the question of exactly how to make use of powerful new technologies while taking heed of the message from the Marvel Comics Spider-man story "with great power comes great responsibility." Applied to the notion of decisions or conclusions being made by powerful AI platforms, if humans, both as individuals and collectively, are not responsible, then, assuming that computers are neither alive nor sentient, there is the possibility that no-one is responsible – unless they understand the interaction between human and automated technology. And we will have nothing to do except experience the impact of decisions and conclusions made by no-one (no person). The antidote to this potential chaos is not to ignore the potential that new technologies and AI may offer (because others will not ignore it), but to proceed carefully and learn diligently how we may want to implement algorithms and AI, including automated and autonomous systems, in a manner that maintains or enhances our capacity to be responsible for ourselves. If we are not able to make use of algorithms, and be in control of them, then someone else will do so (or perhaps the algorithms themselves will be in control).

One possible way to navigate the transitional ethics of responsibility in human and automated systems is to attempt to refuse to participate – we could simply reject the use of computers and automation, and limit all future polygraph activities to the use of methodologies that were developed in the pre-computer epoch. But doing so would have some costs and potential consequences – it could make the polygraph profession more vulnerable to criticism that it is antiquated and subjective. And it could make the profession more vulnerable to future disruption. Another way to proceed would be to permit technology developers to promote the adoption of automated, autonomous, or AI polygraph systems without any thoughtful deliberation or restrictions – just wait to see what happens and deal with it later with no preparation. This too might have undesirable consequences.

A third, middle-ground, solution to the implementation of automated, autonomous and AI systems will be for us to recognize that some forms of computer automation and intelligence are already in place – simply as a result of using a computer. For example, when typing and editing polygraph questions the software "knows" when the text has changed and may prompt the user to save the new work before closing the editor. Or, when saving a list of questions to a computer file, the computer "knows" or "sees" that another file object exists with the same name, and the computer may automatically prompt the user for a different file name. Examples are abundant if we look carefully.

Recognition of potential and existing uses for automation, algorithms, and AI will permit us to make thoughtful and planful decisions about where and how we might wish to make strategic use of available technologies for process automation, literature review, data analysis, and even for hypothesis testing or scientific study. As a general caution, if we neglect to make use of the best currently available technologies we might find that others, at some later time, may use the technology to our disadvantage. One way to accomplish the strategic and effective use of new technology is to create a conceptual map of the various stages of possible implementation. Table 1 shows the different levels of automation that can be achieved through the implementation of algorithms in computerized polygraph systems.

Table 1. Levels of possible automation and algorithm use in polygraph testing.

No automation or algorithm use (analog instrumentation)
Computerized instrumentation
Automated test administration
Automation of basic quality control (e.g., required sensors, stimulus events)
Automated test data analysis
Automated report generation (e.g., analytic result, summary report)
Automation of advanced quality control (data quality, artifacts, countermeasures, questions)

Although tempting, this list should not be viewed as necessarily linear or rigidly hierarchical. It will inevitably occur that some capabilities may be implemented more easily and earlier than others, while some advanced capabilities may remain on the development horizon for the present time. It is also virtually inevitable that some forms of automation may become implemented in ways that are out of sequence with any proposed hierarchy. Some of these capabilities may be only partially implemented. For example, some aspects of test administration, especially some aspects of the pretest interview (e.g., question review and formulation), may be less amenable to automation. And some aspects of quality control may be best left to human expertise (e.g. reviewing the adequacy of test target selection and test question formulation). Also, some of these capabilities may not presently exist; though they are undoubtedly within the reach of eventual development activities. The purpose of this table ismerely to provide organization and distinction for the different capabilities.

0. Analog polygraph instrumentation withmanual polygraph data analysis.

Prior to five decades ago – half a century – the best available technology and best available solution for the recording and analysis of polygraph test data was to use mechanical and electromechanical apparatus to the time-series polygraph signals onto scrolled paper. Nothing about the polygraph testing process was subject to automation. Whereas today the time-series data is recorded in numerical values onto a digital storage media, the ink tracings on the paper were the actual data.

Visual inspection was the best (i.e., only) available technology for polygraph test data analysis in the past. All aspects of data analysis were completed manually, including feature extraction, numerical transformation and data reduction, and the execution of decision rules. Because data analysis was completed with pencil and paper, there was little or no interest in advancing beyond field data-analytic methods that involved integer scores, numerical cutscores, and categorical test results – regardless of the fact that all scientific test results are fundamentally probabilistic. When considering that an algorithm is merely a procedure to be used with some data, and to the degree that it is a structured and standardized activity, manual test data analysis is a form of algorithm.

Analog polygraph instruments remained in use throughout the 1980s and 1990s. However, their use in field practice appears to have diminished substantially since the onset of the 21st century. Old- school analog polygraph instruments are today valued primarily for their nostalgia (and for their more theatric and dramatic visual impression in TV and movie productions).

1. Computerized polygraph instrumentation.

Powerful inexpensive microcomputers began to become widely available about 4 decades ago. The Tandy (Radio Shack) TRS-80 and the Apple II computers were introduced in 1977, the IBM PC was introduced in August 1981, and the Macintoshcomputer was introduced in 1984). Prior to that time, computers were generally much larger, more expensive and available primarily to industry and academic institutions. Computerization of polygraph instrumentation appears to have begun by the late 1980s, and polygraph data sets exist from commercially available field polygraph instruments that were available in the 1990s.

Without any automation, modern computerized are used in a manner that is largely similar to or identical to the way that older analog instruments were used. In this situation the advantage of the computerized system does not extend to data analysis, reliability or validity. There may be some advantage in terms of more convenient operational procedures. For example, the elimination of problems associated with the maintenance of inking and paper mechanisms, and the ability to adjust the display of the time series data after an examination is completed.

2 .Automation of test administration tasks.

Computerized polygraph permit the development and implementation of “wizards” and “expert systems” that can “walk” a user through a required series of step to complete a task correctly. Online customer service chat-bots are an example. In the polygraph context, process automation can increase both the convenience and reliability of test administration. For example: a computer algorithms can ensure that a question template includes the correct sequence of questions and announcements. Or, a computerized polygraph system can prompt a user to close and save an examination before starting a new test. Or an algorithm can remind a user to initiate a new test series when the questions are changed, and can remind a user to start an audio or video recording. Following the completion of a test, computer algorithms can automatically dress or adjust the data to desired or optimal display aesthetics (without changing the recorded data values).

Knowledge of the task, and the required steps, can be thought of as a form of “intelligence” or information that is embedded in the computer, and which the computer will use to assist a user to be more effective, more accurate, or more efficient. In reality, the computer is not actually “intelligent” in the way that we mean when we refer to human intelligence – which involves creativity (creative problem solving), self-awareness, and some system of values (including ethical or moral values) in addition to other attributes and abilities. To the degree that we think of this as “intelligence” it is also artificial. But AI – in the forms that some powerful algorithms are commonly referred to today – refers to computerized or automated capabilities that go beyond the basic execution of programmed procedures.

Some aspects of test administration may be amenable to automation. For example, test question stimuli are traditionally read to the examinee by the examiner butmay be easily read automatically. Thismay be done automatically or cued bythe examiner. Modern digital voice readers in some languages have progressed to a point where they sound so natural that they are easily understood by most, and where further improvement might be potentially unsettling (i.e., it is preferable to some people that robots still sounda little bit like robots so they can easily be distinguished from humans). Use of automated voice readers, and other adaptive technologies, is now so commonplace that there is often very little novelty surrounding their use. For some persons it may be simpler or preferableto make a short digital audio recordingof the examiner's voice.

3. <u>Automation of basic quality control.</u>

Computer algorithms can be easily implemented to perform some basic quality control functions. For example, an automated polygraph system can check tosee whether the examiner has recorded the location, in the time series data, of the announcement of test onset and test end. An algorithm can also check to see if an examination includes all of the questions required for a standardized polygraph technique. It is also possible for computers to determine whether all of the required or standardized recording sensorsare extant and functional.

4. <u>Automated polygraph test data analysis.</u>

Polygraph test data analysis is an obvious potential use for computer algorithms. Algorithms can easily and reliablyperform data analysis tasks that may be more complex and powerful, and possiblymore objective, than visual/manual test data analysis methods. Data analysis tasks include feature extraction, numerical transformation and data reduction, use of some form of likelihood function, and the execution of procedural decision rules to parse the categorical test result from the numerical and statistical information. A wide variety of computer based statistical and data analytic methods exist today, and each of them may have advantages and disadvantages.

As a general rule, automated computerized polygraph algorithms will address these tasks in ways that are somewhat different than the methods used by human polygraph professionals. One important difference is that computer algorithms do not actually see the polygraph data (they lack actual human visual capabilities) but instead process the actual numerical data values. However, it is possible that automated analysis algorithms can be developed to closely approximate validated procedures used by human experts in manual test data analysis. Also, some computer algorithms may fully automate all the necessary analytic functions, and some methods may implement them partially – with some functions completed by human experts.

5. Automated report generation.

Computer algorithms can be used to automate and expedite the production and output of test results and examination reports – including test questions, categorical results, and probability results, in addition to the contact information for recipients of the test results and examination report. Computer algorithms have long been used to process customized reports and these have saved countless hours of typing for professionals who use them. Mail-merges and form letters may be among the most exhaustively used algorithms in the history of micro-computing.

6. Automation of advanced quality control.

In addition to basic quality control functions such as checking for required announcements, events, sensors and charts, automated computers algorithms can be developed to perform some advanced and complex quality control functions quickly, reliably, and easily. These may include the identification of recorded data of unresponsive or unstable interpretable quality. Algorithms can also automate the extraction of data artifacts that may compromise the reliability of data analysis. Data artifacts – which may occur for a variety of causes that may never be known with certainty – can be analyzed for the statistical likelihood that they are the result of faking or countermeasures. Similar to data analysis, some advanced quality control functions may be only partially implemented – leaving some functions to human experts.

Fully automated and unattended poly- graph testing is not likely.

Regardless of available computing power, and regardless of the capabilities of powerful new AI, fully automated and test administration, in which all aspects of test administration and data analysis are completed without the attendance of a human expert or test administrator, appears unlikely at this time and unlikely in the future. And regardless of the degree of automation and implementation of computer algorithms for any of these tasks, decisions pertaining to other humans – especially those decisions that may impact safety, rights, liberties and future well-being – should, for ethical reasons, remain forever the responsibility of human professionals. Outsourcing decisions to a machine process for which no human professional is responsible seems an undesirable option. When algorithms and automation are employed to any degree, human test administrators will remain responsible for the correct use of the methods and technology, while technology vendors and scientists may ultimately be responsible for details pertaining to analysis and validity of those methods.