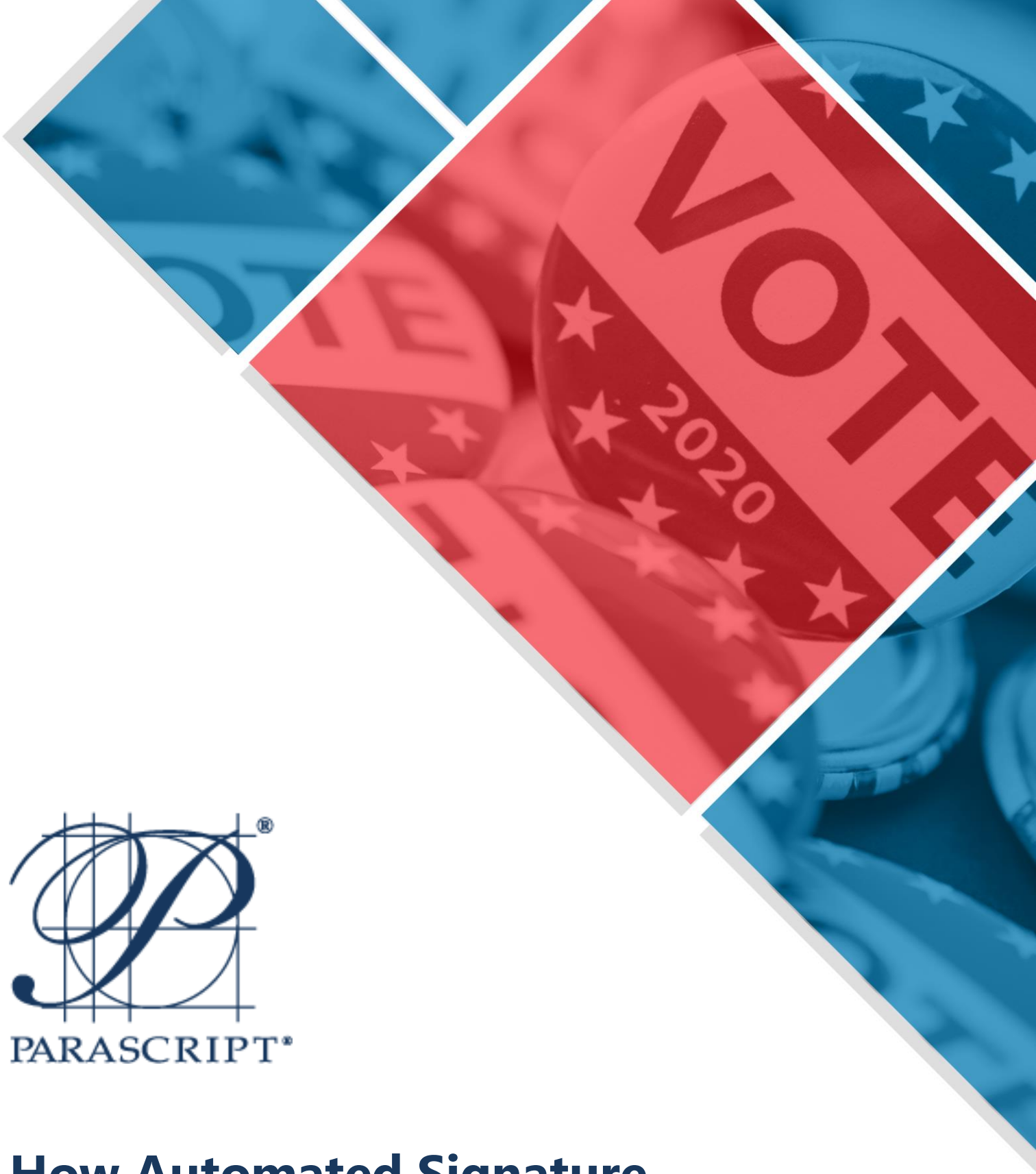

PARASCRIPT®

How Automated Signature Verification Supports Efficient, Reliable Vote-by-Mail Programs

Overview

While "no-excuses" vote-by-mail is offered by thirty-six states and five states have moved to 100% vote-by-mail, there still exists a reluctance to move completely to a vote-by-mail process. Some of this reluctance is based on tradition while another is driven by concerns over security and reliability. In the process to adopt vote-by-mail, there are many aspects to consider to ensure that processes involved produce the highest level of reliability. There is a technology solution to address the issues of security and reliability called **Automated Signature Verification (ASV)** fully explored in this white paper.

What's in this paper?

The #1 Problem: Signature Matching

The most common method employed to ensure that each vote is legitimate is the use of signature match or review whereby each signature on a submitted ballot is compared with signatures on voter records to determine authenticity. In the majority of elections that use vote-by-mail or absentee ballots, signatures are reviewed manually. This causes problems not only in the time and resources required, but also with the ability to reliably compare signatures due to staff who are not always comprehensively trained and with claims that the verification process can be politically manipulated.

Time Costs

The easiest cost to understand is the significant amount of effort it takes to conduct an election and ensure that each ballot is properly reviewed. Part of this cost is related to the time needed to recruit staff to review ballots and then to train them. It's one thing to train volunteers on the tasks needed to manage ballot boxes and verify that ballots are in proper order. This includes ensuring a single ballot is present in each envelope, and that a name and signature are present. However, it is quite another task to train staff on how to compare a signature on a voter record with the signature on the ballot. It is not practical to take someone off the street and train them in a few hours. Intensive multi-day training is required to get the staff even minimally prepared to conduct signature reviews.

There is the actual time required to conduct reviews for each ballot. Ballots are presented to the reviewer along with signatures from voter records and the time required to compare each can take several seconds. While a measurement in seconds may seem insignificant, when the time taken is multiplied against the number of voters and when deadlines for counting votes is applied, even an election that involves 30,000 registered voters represents a significant amount of effort. At minimum, a full week's worth of review to be conducted within 24 hours, not including all the other processes that must be completed.

And then, there are the costs associated with the reliability of the signature review process itself.

Procedural Costs

Signatures are complex bits of information. Unlike typical text or even handwriting, signatures represent a graphical mark that has a lot of complexity within it. It would be difficult enough if the shape and size of signatures were static.

Considering all the ways in which people sign their names—and the associated conditions in which they do it—the ability to reliably match a signature on a ballot with the verified signature on a voter record is seemingly impossible. This problem occurs with every election.

There are verified cases of issues associated with the manual review of signatures. For instance, a 2018 ACLU study found that younger voters were four times more likely to have their absentee ballots rejected than older voters. A Propublica investigation revealed that the signature verification procedures of states varied widely bringing into question the validity of elections, wrongly disenfranchising a large portion of voters. It is a large enough problem that lawsuits have been filed on behalf of voters whose ballots were rejected due to problems with the signature. According to the U.S. Election Assistance Commision, a "non-matching signature" was the number one reason for a rejected ballot.

The Problem with Signatures

People and businesses recognize signatures as the primary way of authenticating transactions. People sign checks, authorize documents and contracts, validate credit card transactions and verify activities through signatures. As the number of signed documents—and their availability—has increased tremendously, so has the growth of fraud. The physical act of signing a signature requires coordinating the brain, eyes, arms, fingers, muscles and nerves. With all of this in play, it is no wonder that people don't sign their name the same way every time: some elements may be omitted or altered. Personality, emotional state, health, age, the conditions under which the individual signs, the space available for the signature and many other factors all influence signature-to-signature deviations.

Signatures are hard to evaluate especially if a reviewer has limited training in the field and limited experience. This is the case when counties are moving into widespread vote-by-mail for the first time. The process may even be harder for certain segments of the population, for example, younger voters might have insufficient experience with handwriting in general and with signing their names in particular. This may lead to less stable signatures which can be rejected by inexperienced human reviewers.

Examples of inconsistent authentic signatures

As another example, signatures of people with old voter registration records may be rejected because signatures can change over time. Such problems may be the cause of potential lawsuits attempting to end the entire practice which could result in more questions of election legitimacy. Lastly, there is the issue of reviewer performance which can is adversely affected by constant, repetitive tasks which create fatigue. The result is a general reduction in accuracy the with each successive hour of manual review.

Automated Signature Verification

There is a solution to this problem called, **Automated Signature Verification (ASV)**. This machine learning-based software takes one or more reference signatures from voter records and compares them with the signature on the ballot to determine authenticity. The process takes less than a second for each ballot. It also produces results that are not only more reliable than results achieved with even well-trained staff, but are consistent and tamper-proof. Even if signatures look different due to changes over time, the software can adapt - looking at key, often hard-to-detect, characteristics that have been proven to remain relatively stable. There is no ability to coerce the software to discard ballots for certain candidates over others so the question of tampering or coercion can be eliminated.

Vote-by-mail also incurs delays in processing, not only because ballots can be received after the official election, but due to the process of evaluating each signature. ASV takes less than one second, which enables vote-by-mail review to occur very quickly.

As additional advantages, this technology allows counties to save significantly on spending, which otherwise would be needed to hire temporary staff for manual signature verification. More importantly, use of ASV minimizes the time required for extensively training staff to be ready for the upcoming election. Automated Signature Verification is already used successfully by banks to evaluate signatures on checks, especially checks with high amounts, to automatically verify legitimacy resulting in significant reductions in fraud while also reducing costs.

The Science Behind ASV

Automated Signature Verification is machine learning-based software trained on literally hundreds of thousands of signatures, both genuine and fraudulent, to identify key characteristics of each that enable high performance. The main advantage of automated signature verification stems from leaving the error-prone human review behind; gone are the risks that stem from exhausted humans, inconsistent training and different capability levels.

Instead, the same algorithm applies to all signature verification, which users can customize for different departments or tiered thresholds for varying levels of risk.

The most advanced signature verification software takes advantage of artificial intelligence systems to imitate the type of analysis that humans perform. It combines this approach with the strengths of computer systems.

In this way, automated systems make definitive measurements and give a more accurate appraisal of signature characteristics that some experts can only estimate using traditional techniques. Comparing enrollment signature measurements to signatures submitted for verification lets automated signature verification outperform trained election personnel and show more accurate and consistent results.

SignatureXpert: A Modern Approach to ASV

SignatureXpert is Parascript's award-winning software that uses a number of different machine learning techniques in order to provide the industry's highest level of accuracy when it comes to automating the complex process of signature verification for elections. It can identify that a signature is authentic even when there is significant variation between the signatures on a ballot and the voter registration. Conversely, it can also identify forged signatures even if two signatures look similar to the naked eye.

Automated verification is completed using a powerful combination of signature analysis algorithms called verifiers. These verifiers employ multiple methods and principles to confirm authenticity. This include a human-like holistic approach to signature interpreting, feature extraction and comparison (using several neural network-based learning and interpretation agents), fuzzy logic and other advanced techniques.

This process allows for the most comprehensive and intelligent analysis of signature characteristics, while taking into consideration the random variations that occur in signatures.

SignatureXpert's verification elements include:

- XR Elements
- Geometrical Analysis
- Analytical Analysis
- Neural Networks

XR Elements

A revolutionary approach to recognition developed by Parascript closely approximates the way humans read and write. This approach, inherent to SignatureXpert and all other Parascript products, uses a special descriptive language based on a set of formative characters or XR elements. XR elements are a set of 64-character motions that can be used in any combination to form all the letters used in handwriting.

Suspect and reference signatures are presented as sequences of XR elements and compared, using multiple factors. Non-linear transformation is found that allows correlation between XR elements belonging to different signatures. The system of estimates is built and passed to several neural network-based learning and interpretation agents to fulfill a fine analysis and make a conclusion about the similarity of two signatures. An example of correlation between the XR elements belonging to two signatures is shown in *Figure 1*.

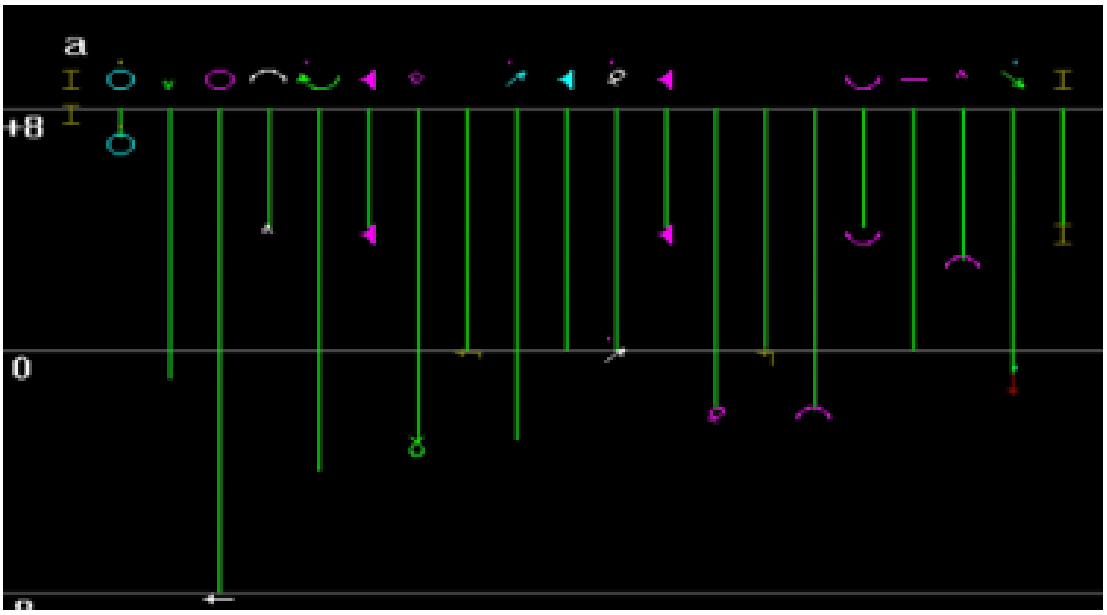

Figure 1. XR interpretation of the correlation between two signatures.

Geometrical Analysis

Geometrical analysis of the suspect and reference signatures complements the holistic approach and makes verification more efficient. In this method, similar nodes (distinctive elements) of a signature are found in the suspect and reference signatures (see *Figure 2*). Triads of these nodes are used to build triangles with apexes located in the selected nodes. The triangles' similarity—belonging to different signatures—is analyzed and used to make a conclusion about authenticity.

Analytical Analysis

In addition to the verification methods mentioned above that look at the signature as a whole, analytical methods look at segments of the signature. This method uses algorithms to look at fragments of the reference and suspect signatures (see *Figure 3*). Because this method uses fundamentally different principles than the holistic approach, it is very efficient in cases where the holistic approach cannot ensure the required reliability level of a result.

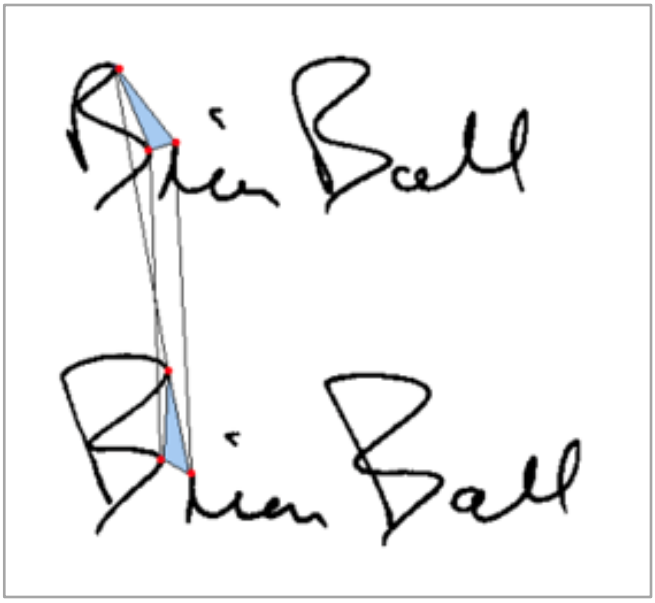

Figure 2. Geometrical interpretation of signatures.

Neural Networks

A global verifier, based on neural networks, estimates and compares more than 30 different characteristics of the image, including: aspect ratio, orientation, slants, curves, etc. A combination of methods, based on different principles, successfully distinguishes between variations in a person's handwritten signature and distortions inherent in the skilled and random forgery.

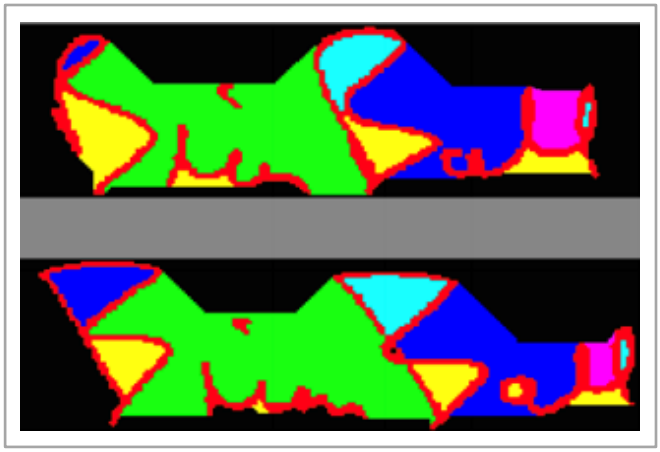

Figure 3. Signature fragments comparison.

Verification Results

After the verification process, SignatureXpert issues a confidence value that indicates how confident the software is about the match between the signature presented for verification and the authentic reference signature. A high confidence value indicates a high probability that the signature presented for verification was written by the same person as the reference signature.

ASV in Ballot Processing

As described by a Joint COVID Working Group that is part of the Cybersecurity and Infrastructure Security Agency (CISA) , use of ASV can be reliably applied to a multi-step process that "promotes transparency and integrity. In this process, ASV provides the first-pass analysis on all signatures with human review reserved for ballots that do not match in that first stage. A third pass handles the difficult cases where neither the software nor the human review can arrive at a conclusion.

Automated signature verification can also be used to audit and improve human performance. In a two-way audit, a random sampling of results from automated verification are reviewed to identify the level of performance. And a random review of human verification against results from ASV can also reveal the need for additional oversight and training of staff. Together, the system and the staff aid each other to make a more-reliable and more-efficient process.

Conclusion

Automated Signature Verification is used today in many states' vote-by-mail processes to provide solid assurances that each vote is treated fairly and thoroughly reviewed. States such as Oregon, Colorado, Washington and Utah provide solid examples of the *new gold standard,* using ASV technology alongside other solid processes to ensure that every election is efficient, legitimate and secure. For instance, Colorado—which overhauled its signature verification process after an incident involving forged signatures on petitions—now has a model that includes ASV. Denver County, for example, submits every ballot into ASV software, which provides automated verification on a large percentage of ballots leaving only a smaller segment to be reviewed manually. This process has been successfully emulated by a number of municipalities in Colorado and other states.

As states evaluate and implement vote-by-mail to support the upcoming election and elections in the future, automated signature verification should be a necessary component in their plans.

About Parascript

Parascript automates the interpretation of meaningful, contextual data from image and document-based information to support fraud prevention, information governance, transactions and business processes. Parascript provides Smart Learning intelligent capture for any document with any data from any source with its easy-to-use, image-based analysis, classification, data location, data extraction and verification technology.

More than 100 billion documents for financial services, government organizations and the healthcare industry are analyzed annually by Parascript software. Parascript offers its technology both as software products and as software-enabled services to our partners. Our BPO, service provider, OEM and value-added reseller network partners leverage, integrate and distribute Parascript software in the U.S. and across the world. Visit us at **Parascript**.

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