Technical Report:
100% Retabulation Audits: 2022 Primary and General Election Audit Data and Ballot Images from Leon County, FL

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Abstract: We developed a 2022 audit primary and a general election data dashboard that includes images of the ballots voted in Leon County. These data are embedded in a web page on a website we built for this purpose. Additional pages on the website describe postelection audit processes, data produced by election officials to verify the election outcomes, interesting ballots found in the data, and information on how to use the dashboard. Throughout the project, we faced many obstacles to presenting these types of data in an accessible format, including protecting voter privacy and ballot secrecy, correcting ballot orientation, managing the quantity of the data presented, speed and performance in data presentation, developing the dashboard design, and creating a web design and useable layout.

Background on Postelection Audits

Free and fair elections are one of the pillars of American democracy, but ensuring a healthy democracy via a safe, secure, and efficient election process involves more than just making certain that elections work well. The public must perceive that voting is easy and accessible, their privacy is protected and that results are determined fairly and accurately, without partisan bias or technological flaws.

Election auditing is a critical component of election security and integrity. Today, 45 states perform some sort of postelection audit, and two additional states have postelection audit pilot projects to ensure the accuracy of tabulators and the election outcomes.[1] Postelection audits are meant to be a public check on the voting system. Transparency around postelection audits helps to ensure a fair and accurate election process that maintains voter privacy, while also helping to minimize the potential for fraud.[2] Their purpose is to ensure only eligible voters participated in the election and that the equipment used to count ballots worked correctly and produced accurate results.[3]

At a time where some voters doubt the accuracy and veracity of elections, postelection audits can be a powerful tool to assure the public and especially stakeholders (candidates, election staff, etc.) that the results accurately reflect the will of the people. Therefore, our projects seek to expand election transparency and enhance election integrity through a pilot project that presents the data from the 2022 primary and general election postelection 100% retabulation audits in Leon County, Florida, including images of the ballots, in an accessible and public space. The audit shows that two independent tabulators produce the same winners and therefore count votes accurately.

While the task seems simple, there is a lot of variation in how states conduct postelection audits and there are many ways to present the collected data. There is no standardized format across jurisdictions to present and inform voters of the outcome. Moreover, despite the theoretically public nature of postelection audits, less than half of the states make data from the postelection audits available in usable form for the public or researchers to examine (Jaffe et al 2023). If data are not available for review, an audit cannot impact public confidence. In addition, there are many issues related to voter privacy, ballot secrecy, and vote buying that need to be considered when making ballot images and other audit data public.

Our applied case study addresses these issues by developing a 2022 audit data dashboard that includes images of nearly all the ballots voted in both the primary and general elections in Leon

[1] NCSL, Postelection Audits, available at: https://www.ncsl.org/research/elections-and-campaigns/post-election-audits635926066.aspx#state%20reqs.
[2] See Huefner, Steven F., Daniel Tokaji, & Edward B. Foley. 2007. “From Registration to Recounts: The Election System of 5 Midwestern States,” available at: https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/b/90788/files/2021/05/From-Registration-to-Recounts.pdf.
[3] See U.S. Election Assistance Commission. "Election Audits Across the United States." https://www.eac.gov/election-officials/election-audits-across-united-states.

County, Florida. The primary and general election data are embedded in two separate web pages on a website we built for this purpose. Additional pages on the website describe postelection data processes, present data produced by the state and county to verify the election outcomes, offer images of "interesting" ballots found in the data, and provide information on how to use the dashboard.

You can find our dashboards and website here.

It is worth noting that throughout the project, we faced many obstacles to presenting these types of data in an accessible format. Obstacles included protecting voter privacy and ballot secrecy, correcting ballot orientation for viewing the images, managing the quantity of the data presented, enhancing the speed and performance of data presentation in the dashboard itself, developing the dashboard design, and creating a web design with a useable layout.

Data and Methods

Information about Leon County, Florida

Leon County is home to Tallahassee, the capitol of Florida. It is located in the state's panhandle. Leon County has roughly 203,000 active registered voters and is considered a medium-sized jurisdiction.[4] It is a predominantly Democratic County with a majority (50.8%, (100,427) registered Democrat, about three in ten (29.7%, 58,783) registered Republican, about two in five (19.9%, 39,834) registered No Party Affiliation (NPA), and 1.8% (3,564) registered in some other nonmajor party.[5]

The 2022 statewide primary was held on Tuesday, August 23, with early voting available to all eligible voters from August 13-20. The general election was held Tuesday, November 8, 2022, with early in-person voting available from October 29-November 5. Florida also has a no excuse vote-by-mail policy that many voters take advantage of. Vote-by-mail ballots could be returned either by mail, at the Supervisor of Election's office, or at mail ballot drop boxes by 7 PM on Election Day.

The primary election in Florida is closed. That means that only registered partisans can participate in their party's primary election. However, in Leon County, city and county contests are nonpartisan and open to any eligible voter in the county. These facts led to 3 ballot types in the primary: 1) Democratic and nonpartisan contests; 2) Republican and nonpartisan contests, and 3) Nonpartisan contests only. Democrats made up 41,226 voters, Republicans made up 19,297 voters, which leaves a paltry 6,348 non major party identifiers, including NPAs, voting for a total of 66,871 ballots cast. The smaller turnout for non-Democrats led to ballot privacy concerns among ballot images especially for the primary, which we discuss in detail below.

[4] See: https://www.leonvotes.gov/ for recent data on voter registration.

[5] These data come from the Leon County Supervisor of Elections website, are time stamped August 1, 2023, and can be found in their current form here: https://www.leonvotes.gov/Portals/Leon/Documents/Data_Lists/Current%20Data/Snapshot/Active%20Voters%20by%20District.pdf

In addition, in Florida when a contest has only one candidate running, it is excluded from the ballot and the candidate wins by acclimation. Therefore, there was large variation in the number of contests across ballot types. Democrats had the longest and most interesting ballot, with a statewide (somewhat) competitive gubernatorial contest that was primarily between former Governor Crist and Agricultural Commissioner Nikki Fried. Also on the Democratic ballot were a statewide US Senate contest, Attorney General contest, and Agricultural Commissioner contest, all of which were less competitive than the gubernatorial contest, but still had multiple contenders.

Republicans had one statewide contest, the Agricultural Commissioner, but it was not particularly competitive, which likely helps to explain the dismal turnout for Republicans. In addition, there were two nonpartisan contests, one county judge contest and one county commissioner contest in which all voters could participate. Down ballot contests for which only some voters could vote included contests in House Districts, county commission districts, school board districts, and city mayor and city council seats.

The shortest Democratic primary ballot voted on seven contests, while the longest voted on 12 contests. The shortest ballot for Republicans was four contests and the longest was eight. The shortest nonpartisan ballot was three contests and the longest was seven.

In the general election there were a total of 117,456 voters: 61,696 were Democrats, 37,860 were Republicans, and 17,900 were non major party identifiers including NPAs.

Data

We obtained the data from the Leon County Supervisor of Elections for the 2022 primary and general elections in Leon County, Florida. We received the primary data on September 19, 2022, and the general election data on June 5, 2023. The data come from the auditing system used by the Leon County Supervisor of Elections – the ClearAudit system – and include:

- An image copy of both sides of the ballot for all ballots cast in Leon County, Florida. In the primary, there are no contests on the back side of the ballot, but contests take up both sides of the ballot in the general election.

- The audit summary that includes an aggregate comparison of the vote totals, undervotes, and overvotes for each candidate between the official vote count and the audit tally. The official vote count comes from Dominion tabulators. The audit tally comes from a ClearBallot tabulator.

- The audit cast vote records (CVR) contain detailed information for each ballot on whether a vote was cast in a contest, and if so, for which candidate(s), according to ClearAudit's determination based on the markings on the ballot. The audit CVR also includes information on precinct, vote mode, and language associated with each ballot.

- The audit oval confidence files that include a confidence score or ranking for each oval within a contest (i.e., candidate or choice)[6], grouped by vote mode (Election Day, Early Voting, or Vote-by-Mail) and ballot disposition or vote type (vote, undervote, overvote, or vote for an alternative candidate).

We supplement the audit data with other state and county-level voting records, including the county and state canvass.

Data Processing

For our dashboard, we first cleaned the audit summary to show for each candidate: (1) the contest, (2) for the primary elections, also the party of the contest (Democratic Party, Republican Party, or nonpartisan races), (3) total ovals counted according to the official system (Dominion), (4) total ovals counted according to the audit system (ClearAudit), (5) the difference in ovals counted by the two systems, (6) total votes recorded according to the official system (Dominion), (7) total votes recorded according to the audit system (ClearAudit), (8) the difference in the votes recorded by the two systems, (9) total overvotes recorded by the audit system (ClearAudit), and (10) total undervotes recorded by the audit system (ClearAudit).

We also merged the audit CVR and the audit oval confidence files to show the following in our dashboard: (1) ClearAudit's determination for each oval (i.e., choice, meaning candidate) on each ballot based on the markings or the lack thereof (vote, undervote, overvote, or vote for an alternative candidate), and (2) the confidence ranking the ClearAudit system places on its determination by vote mode and determination. In the same table, we also show whether each ballot is an Election Day, early, or mail ballot and provide a link to the ballot image.

For our analysis of the audit data, we further append the precinct-level election results to the audit CVR and oval confidence files. Combining the audit data and the precinct-level election results allows us to identify potential ballots that explain the differences between the official and the audit counts.

Auditing Methodology

Leon County uses Dominion hardware and software for its official ballot tabulation. The software and hardware are certified by the state of Florida. For its official tabulation, the county uses Dominion based products, including Dominion's Democracy Suite software for its in-person systems and Image Cast Central software for its mail ballot software.[7]

Leon County uses the ClearBallot ClearAudit for the 100% retabulation audit. All ballots are inserted into the ClearAudit tabulator at the Leon County Election Center. ClearAudit is a

[6] We say choice because some of the items on the ballot were amendments or other nonoffice ballot questions.
[7] See Florida Secretary of State's page about vote tabulation certification here: https://dos.myflorida.com/elections/voting-systems/about-voting-systems/ and a list of what each county used in 2022 here: https://files.floridados.gov/media/705877/voting-systems-in-use-by-county-20220830.pdf.

browser based central count tabulation system. ClearAudit can tabulate ballots created by all major voting systems certified in the state of Florida, offering a truly independent retabulation. By independent we mean that there is no hardware or software in-common between the official (Dominion) tabulation systems, and audit (ClearBallot), tabulation systems.

The tabulators use different methods to identify votes. Dominion software searches for a vote by starting at the center of an oval and moving outward to its ends. ClearAudit software uses a larger zone fully encompassing the oval for each contest to search for and identify a vote for each candidate. By looking at a larger contest area around the oval, the ClearAudit system can identify stray marks and marks outside of the oval that could be a vote. For example, if someone circles the oval instead of filling it in, the ClearAudit system will see those marks and can better identify whether those are likely votes or not. ClearAudit's software also includes a vote visualization tool that potentially allows auditors to find uncounted or incorrectly counted ballots.

Once the election officially begins, Florida County Election Supervisors are allowed by statute to process and record mail ballots as they arrive.[8] Immediately after these ballots are processed by the Dominion high-speed tabulator, they are taken to the ClearAudit tabulator and processed a second time. Ballots from early voting are counted by the Dominion ICE tabulators on site and then are transported to the election center at the end of each day of early voting and processed through the ClearAudit tabulator the next morning at the election center. Ballots from Election Day are transported to the election center on election night and are inserted into the same ClearAudit tabulator for counting the next day.

In Leon County, ballots are read into the ClearAudit tabulator over the course of the election. Ballots are tabulated within mode by batch and given consecutive numbers such that the first batch tabulated is designated by its mode (mail =VBM, Election Day=ED, and Early Vote-EV) and then its batch (001, 002, etc.). The first ballot tabulated within each batch starts the counting at 1. So, the first ballot of the first batch of vote by mail ballots counted by the ClearAudit tabulator would be VBM-001+100001, the second ballot of the first batch of vote by mail ballots would be VBM-001+100002, etc. The ballot images record this number in the file name, so the numbering scheme can be used to locate the ballot image of a particular ballot.

Making a Dashboard

The primary goal of our project was to make the audit data and ballot images accessible to the public for review. To accomplish this, we built a webpage and a data dashboard for both the primary and the general elections. The dashboard contains all the ClearAudit audit data and links to the ballot images.[9]

Our first attempt at making the dashboard was in *Tableau* and included only the primary election data. We spent a lot of time and resources designing the dashboard and making it user friendly. While the appearance of the dashboard was acceptable, due to the size of the data, it was unusable. We upgraded the dashboard from the free version of *Tableau* to the enterprise version

[8] Florida Statutes Section 101.68(2)(a).
[9] See our dashboard page here: https://2022voterdata.lci.fsu.edu/dashboard/2022-general-election/.

of *Tableau*, but we ultimately ran into the same issues. Much of the data would not load at all, and when it did, it was incredibly slow.

After determining that Tableau was not a viable option, we considered *Microsoft's Power BI* and the *R* package *Shiny,* both of which are designed to make interactive apps for displaying data. After making drafts of the primary dashboard in each program, we determined that *Shiny* was the best option for two key reasons. First, the user experience on the dashboard using *Shiny* is better, as we have more control over the user interface. Second, since the *Shiny* dashboard uses code to create the app, we can reproduce the dashboard for multiple elections with relative ease, maintaining consistency with the dashboard appearance and interface so long as the data are structured the same way each time. With *Power BI*, each election would necessitate creating a new dashboard.

This choice does not come without its drawbacks. While the data loads significantly faster in the *Shiny* app compared to *Tableau*, with the *Shiny* app taking just under 45 seconds to load the primary election data as opposed to the *Tableau* dashboard which took more than a minute, *Power BI* loaded the data instantly. We did not attempt embedding the Power BI version of the dashboard into the website, but in our tests, it was able to load the data nearly instantly. Furthermore, the *Power BI* dashboard was able to load ***all*** the data instantly, while the *Shiny* app dashboard loads the data in chunks of 10,000 rows of the data on each page. While this is minimally disruptive to the user's experience, we felt that it was worth that sacrifice for the other benefits of using the *Shiny* app, such as the appearance of the dashboard as well as the overall usability and replicability of the dashboard. The *Power BI* dashboard was unable to include the Leon County precinct map, which was another reason to go with the *Shiny* app. Furthermore, *Power BI* was overall more restrictive on how we were able to present the data.

We were also under the impression that *Shiny* would be completely free due to *R* being entirely open source. While it is true that creating the dashboard itself was free, and the dashboard for the primary audit was able to be hosted for free, due to the size of the data in the general election audit, we were required to upgrade to a paid account with *Shiny*. While the primary election app was able to be uploaded to *Shiny* for free, there were limits on the amount of RAM our app could use for free, and we exceeded those limits for the general. That said, the cost of the account with *Shiny* is comparable to, although slightly greater than, the cost of a subscription to *Power BI*.

The *Shiny* app dashboard utilizes a combination of *R* code, specifically from the *tidyverse, sf, DT, plotly, Shiny, Shinydashboard,* and *htmltools packages, CSS, and JavaScript.* The *tidyverse* code was used to clean the data within the dashboard, such as changing column names for the two tables. *Tidyverse* code was also used with code from the *Shiny* package to filter the tables in response to the interactive elements on the dashboard, including the dropdown menus for party and contest, as well as the checkboxes for vote type and vote method. Code from the Shiny package was utilized to make the base elements of each dashboard, such as the dropdown menus, and the DT package was used to create the two tables. Some elements of the tables were not able to be changed with *R* code, such as the summing at the bottom of the first table, and JavaScript was used to add these elements. JavaScript was also used to ensure the sizing and placement of the map would fit in the bounds of the dashboard. The *sf* package was used to load the shape file for the map of Leon County's precincts, and the *plotly* package was used to create the map. The

map is static for the primary election to protect voter privacy in smaller precincts but is fully interactive in the general election dashboard.

All of the aesthetic elements of the dashboard were changed using CSS code. This includes the color, size, and shape of each element of the dashboard. The placement of each element of the dashboard was determined through a combination of *Shiny, Shiny dashboard*, and CSS code. One concern we had with making the dashboard was to ensure that it would be accessible to users on a wide range of devices. We determined the best dimensions of the dashboard through trial and error, testing the dashboard's appearance on larger, 27-inch monitors, and small, 13-inch screens, to ensure that the dashboard would fit in a wide range of applications. The dashboard is not mobile phone friendly due to the size and complexity of the data.

Describing the Dashboards

Figures 1 and 2 show screenshots of the dashboards for the primary and general elections.

Figure 1. Image of Primary Election Dashboard

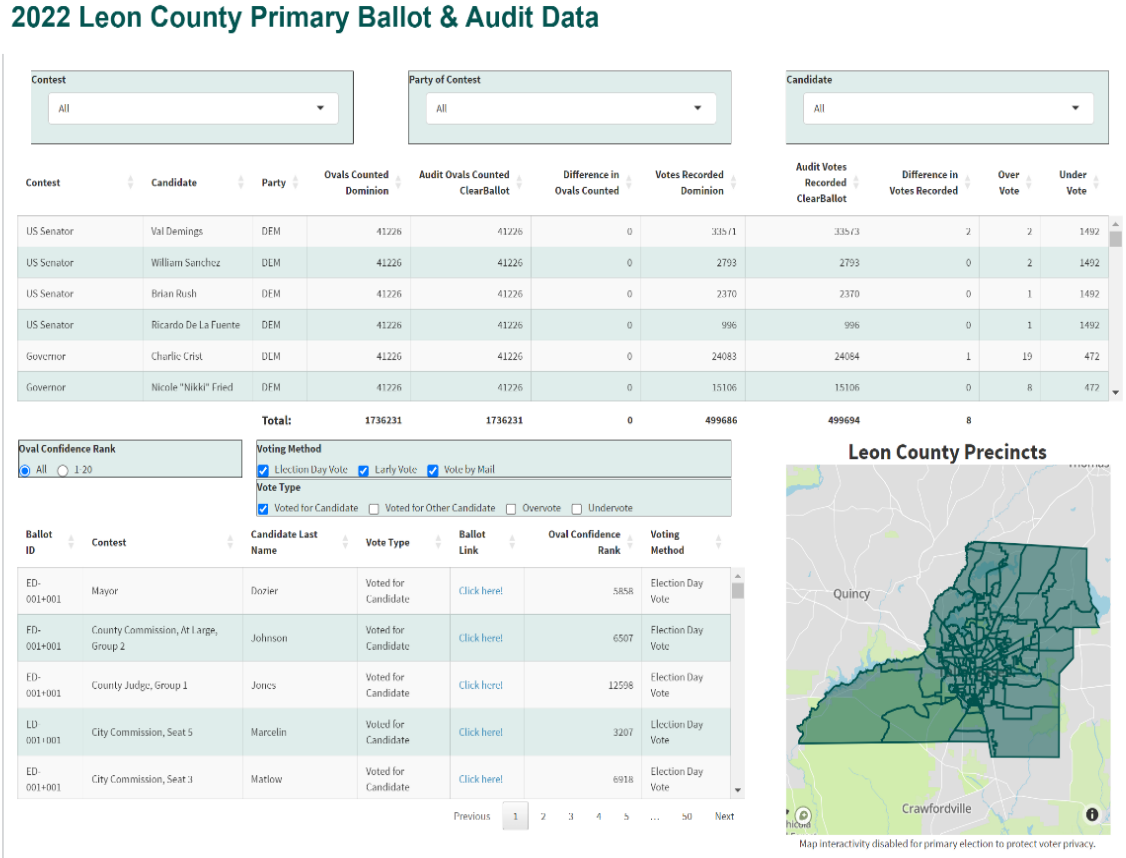
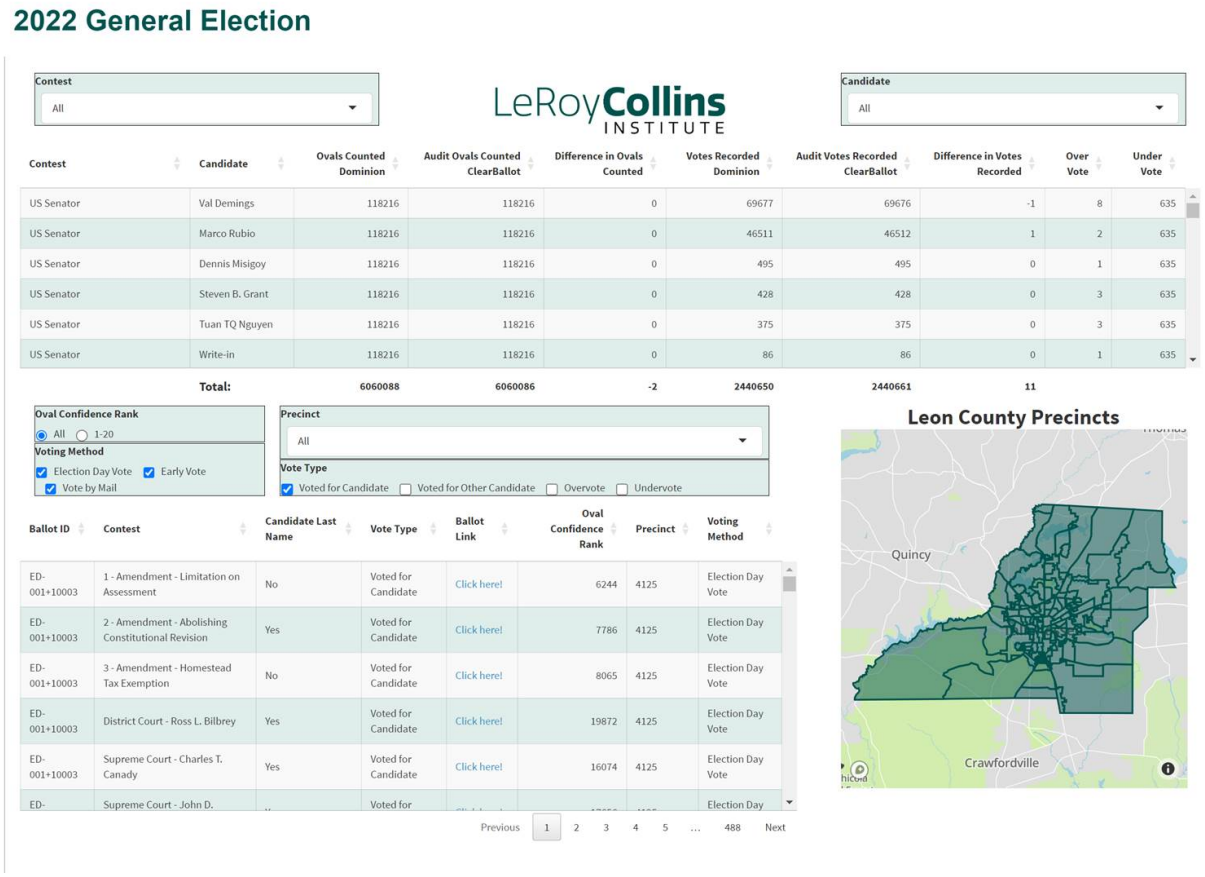


Figure 2. Image of General Election Dashboard



The 2022 Primary Election Dashboard

Focusing first on Figure 1, which presents the primary election data in a table format, there are three filters at the top of the dashboard. The first filters the data and corresponding ballot image links by contest, the second filters by candidate, and the third filters by party.

In Figure 2, which presents the general election, there are only two filters, contest, and candidate because party does not make sense when we move to interparty competition. These filters manipulate data in both Table 1 and Table 2 of the dashboard, which have nearly identical categories or columns of data for both the primary and general elections. Table 1 shows the aggregated auditing data from the ClearAudit tabulator. The order of the contests in filter 1 is the same ordering found on the ballot, therefore the Democratic US Senate contest is at the top, followed by US House, then Governor, etc.

The ClearAudit audit system examines each oval, so the total count at the bottom of the table reflects that. For example, if we were to filter the contest for the Democratic nomination to the Senate contest we see 4 candidates and there are 41,226 ballots or voters. To calculate the total number of ovals, the calculation is 41,226 ballots X 4 candidates, which equals 164,904 total ovals counted. Every oval gets a disposition code or count, which includes 1) vote for candidate, 2) vote for other candidate, 3) overvote, or 4) undervote. Thus, while there are nearly 165,000

ovals recorded in the US Senate contest there are only 41,226 eligible voters participating in this contest.

The third and fourth columns show the number of ovals counted for each candidate. This should be the total number of eligible voters that participated in the election. These numbers should be the same across systems and subtract to zero, which they do, as shown in column 5. If these numbers were not the same, that would suggest that one tabulating system counted more ballots than the other and there could be questions about ballot chain of custody, ballot design (tick marks), or related issues.

Columns 6 and 7 show the number of votes counted for each candidate in a particular contest first for the official tabulation and then for the audit tabulation. For example, Democratic Senate candidate Val Demings received 33,571 votes on the official count and 33,573 votes with the ClearAudit System. Column 8 shows the difference between the official vote count and the audit vote count. In the case of Val Demings, two more votes were found on the ClearAudit system than the official first tabulation system. This suggests that ClearAudit converted two votes that were not counted and were likely considered undervotes in the first tabulation of votes for Demings.

Column 9 shows the overvotes and column 10 shows the number of undervotes as recorded by the audit system. Overvotes are when a voter votes for two or more candidates in a contest and therefore the votes go uncounted. Undervotes are when voters choose to skip a contest and not vote for any candidate. In the case of Val Demings, the data show that there were seven ballots that included an overvote for Senate and out of the 41,226 eligible voters 1,492 chose not to select any candidate for US Senator and therefore undervoted.

All in all when we look at the primary dashboard results across all the primary contests, we can see that there is only an 8 vote difference between the first tabulation and the second audit tabulation. That is 8 out of 1,736,232 ovals counted, or a 99.9985% match. In all cases in the primary election, it is because the ClearAudit system found and counted one or two more votes than Dominion. It found one extra vote in each of the following contests: the gubernatorial race, the Democratic Commissioner for Agriculture, County Judge, County Commissioner at large, County Commissioner District 5, School Board District 1, and the mayor's race; and, it found two extra votes in the Democratic US Senate Contest.

2022 General Election Dashboard

In the general election example, shown in Figure 2, we can see that with nearly twice as many ballots there is more variation across the two tabulation systems than we saw in the primary. The first table is identical in layout for both dashboards, but the general election only has two filters at the top, one for contest and another for candidate. Because this is not a primary contest with party ballots, we did not include a party filter.

In the general election, there were a total of 45 discrepancies in votes recorded between Dominion and ClearAudit out of 6,060,088 ovals counted. This translates to a 99.9983% match. We see some cases where ClearAudit found one more vote to count than Dominion (e.g. Governor DeSantis, Attorney General Moody vote, State Senator Simon vote District 3, Supreme

Court Couriel vote, District Court votes for Kelsey, Long and Rowe, County Commissioner Johnson, Mayor, and the contests for all three amendments). And a few cases where ClearAudit found 2 or 3 more votes to count than Dominion (both Commissioner of Agriculture candidates, and Supreme Court retentions for Canady, Grosshans, Labarga and Polston). We also see a handful of cases where Dominion counted one more vote than ClearAudit (US Senator Demings, Representative Lawson, CFO Hattersley, State Senator Ausley, State Representative Franklin, Supreme Court retentions for Canady, Couriel, Labarga and Polston, District Court retention votes for Bilbrey, Long Winokur, County Commissioner O'Keef, and School Board District 3 Jones), and one case where Dominion counted two more votes (Mayor Dozier).

Three contests (State House District 8, and County Commission Districts 2 and 5) show differences in the number of ovals counted. In the case of the State House District 8, there are two candidates that had one fewer counted oval in the audit than in the official tabulation system. This is an odd result, and we are not sure how to interpret it at this time. The county ignores the difference because it does not change any outcomes, but it seems to suggest that there may be a capture problem that should be more closely examined. It does not appear in other races in which these contests are nested, so it appears to be likely an intra ballot counting problem and not a missing ballot or chain of custody issue. Something similar is seen in County Commission Districts 2 and 5.

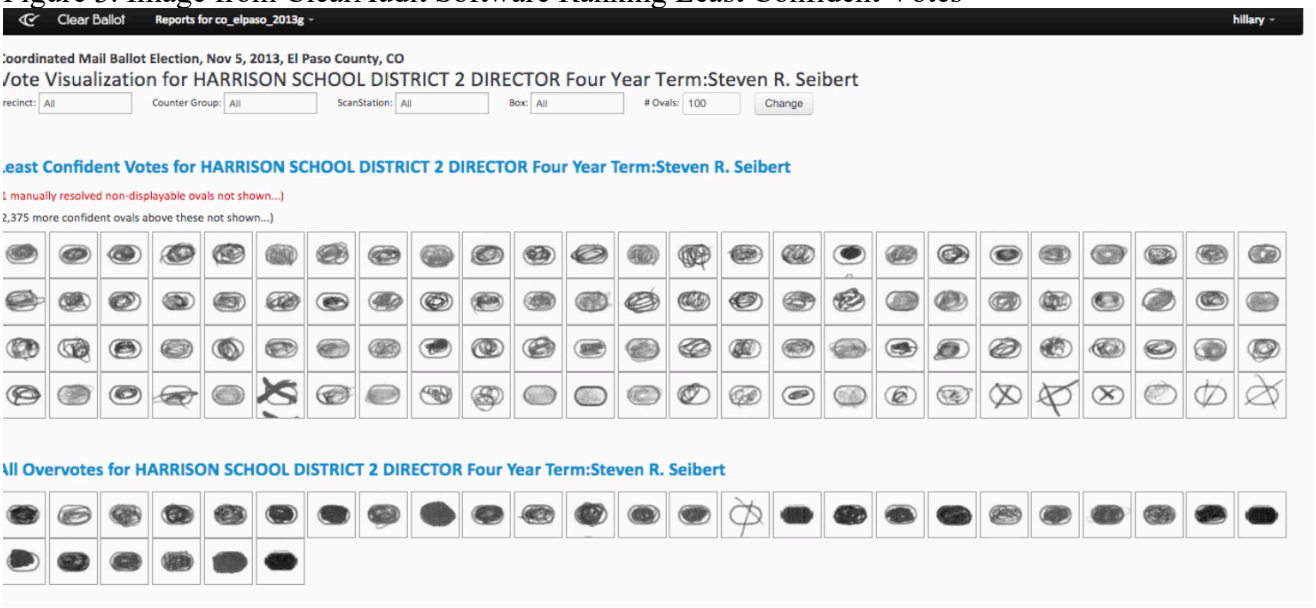
The US Senate contest consisted of six candidates, including a verified write-in candidate. We see that in Leon County, Val Demings won the most votes, and this was consistent across both vote tabulators. Each vote tabulator recorded the same number of ovals, indicating it read the same number of ballots. However, in terms of votes recorded, Val Demings received one less vote and Marco Rubio received one more vote in the ClearAudit tabulation system than in the official voting system. Because they recorded the same number of ballots it is not the case here that the ClearAudit tabulator found an additional vote, but instead the two tabulators appear to have counted one or more ballots differently. There is no way to know exactly which ballot or ballots those might be, though ClearAudt would suggest starting with the ballots with the lowest confidence ovals in these races (see more below under *Finding Discrepant Ballots*).

In the general election, unlike in the primary, we see several examples where it looks like a ballot was counted differently because it does not appear as if any new votes are found. The same number of ovals are counted in each contest, but they are allocated to different candidates. Besides the Senate contest, this also happens in the Florida US Congressional District 2, where there is one more vote for one candidate and one less vote for the other candidate. We see the same type of discrepancy for the Chief Financial Officer, State Senate District 3, State House District 3, and on the retention question for judges (Canady, Couriel, Labarga, Polston, Long), and Mayor.

We also see that District Court Candidate Bilbrey had two fewer votes and Winokur has one fewer vote in the ClearAudit system than in Dominion. We also see one fewer vote counted in the County Commission District 5 contest and the School Board District 3 in the audit count than in the Dominion count. Among the amendments, we find several instances where ClearAudit was able to capture one more vote.

Table 2 in each dashboard, or the table at the bottom of the screen, displays the ballots and provides links to the ballot images. Ballots are displayed one at a time by clicking on the "Click here" link under the column labeled "Ballot link." The Ballot ID is the batch number followed by the ballot number in that batch as described earlier. Ballots can be sorted using the filters at the top and the filters in the middle of the screen, including oval confidence, ballot mode or voting method (e.g. early, Election Day, or vote-by mail), and vote type, which is the oval disposition codes (e.g. vote for candidate, vote for other candidate, undervote, overvote). ClearAudit produces a confidence ranking for each oval on the ballot and in Figure 3 we show an example screen shot of the ClearAudit oval rankings. In the ClearAudit software, a user can hover over an oval and the ballot contest will pop up for review. The photo shows the 100 least confident ovals. The last oval is the least confident, the first oval is the 100th least confident ovals. We captured the confidence rankings and included it in our data set. A user can click to filter the 20 least confident dispositions of any type or select all.

Figure 3. Image from ClearAudit Software Ranking Least Confident Votes



Finding Discrepant Ballots

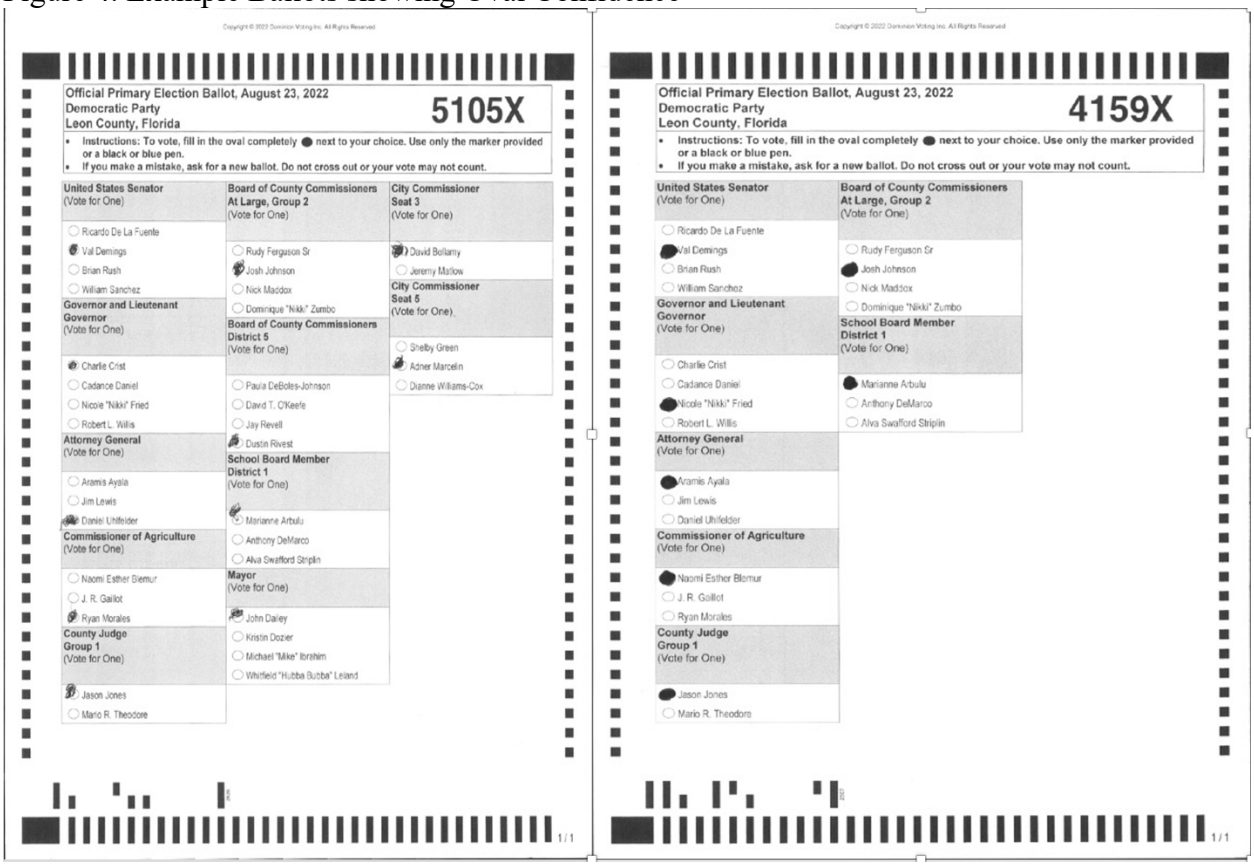
Of course, we do not have the ClearAudit software, only the dataset it produced. Therefore, we have to sort and search through ballot data and images to attempt to identify any discrepancy. The audit data in our dashboard contains this feature because it allows the user to identify the 20 least confident ovals by vote type (vote for a candidate, vote for an alternative candidate, undervotes and overvotes). We limited it to 20 because after the first few ovals it is impossible for the human eye to discern differences in oval quality. However, a user can click on the vote type column and obtain the full rankings that we have from 1 to *N*.

In Figure 4 below, we show a photo of the School Board District 1 contest from the primary election. This was a 3-way school board race with candidates Marianne Arbula, Anthony DeMarco, and Alva Swafford Striplin. It shows that the ClearAudit system found one more vote for Arbulu than Dominion. By comparing the official precinct results to the results of the

ClearAudit system we were able to identify in which precinct the ClearAudit system counted one more vote and then used confidence data in that precinct to help identify the likely ballot that was not counted by Dominion but was counted by ClearAudit.

The ballot on the left represents the least confident oval in this contest in the precinct where the discrepancy exists and the ballot to the right represents the most confident oval. The ballot to the right has neatly colored, dark ovals, while the ovals on the left are somewhat poorly filled in with the school board race showing most of the coloring on the outside of the oval. In this case, the ballot on the left was not counted by the Dominion machine, but the ClearAudit tabulator, which looks at the larger "contest zone," surrounding an oval returned a vote for Arbula.

Figure 4. Example Ballots showing Oval Confidence



Using the Map for the General Election

One last feature we included in our dashboard is a precinct map for Leon County. Because of ballot privacy issues, we had to exclude an interactive map for ballot selection by precinct for the primary election, but it does work for most of the precincts in the general election. For 21 smaller precincts, we had to combine them into groups of two or three to protect voter privacy in the general election.

Ballot Image Data Facts

On our website, we included several interesting ballot buckets for voters to review. These include ballots with no votes, ballots with signatures, other interesting ballots with marks, and ballots with overvotes for the gubernatorial primary, which has poor directions, "Governor and Lieutenant Governor (Vote for One)," creating confusion for a small set of voters.

In addition, our close look at the primary provided some interesting descriptive facts. For example, the cast vote record allowed us to explore how voters interact with their ballot. Table 4 shows that around 81% of voters voted in every contest on their ballots and this was roughly true for each party ballot and regardless of the number of the contests on the ballot. Of course, voters who only voted in the nonpartisan races had the fewest number of contests to consider, perhaps this is why they have a slightly higher completion rate, on average, than Democrats or Republicans.

Table 4. % Ballots Completed by Party, Leon County 2022 Primary

	Democrat	NPA	Republican	Total
100% Complete Ballot	79.7	85.9	80.8	80.6
N	32,849	5,452	15,585	53,886
< 100% Complete Ballot	20.3	14.1	19.2	19.4
N	8,377	896	3,712	12,985
Total	41,226	6,348	19,297	66,871

Table 5 shows that 49 or .07% voters voted a blank ballot. These voters apparently wanted the voter credit but had no candidate preferences. We also found that 644 or almost 1% of voters came to the polls to vote for only one candidate. We have placed the ballots in which there are no votes under interesting ballots for user examination.

Table 5. % Ballots Voting in No or Only 1 Contest, Leon County 2022 Primary

	Democrat	NPA	Republican	Total
Voted in 0 Contests	0.03	0.20	0.12	0.07
N	13	13	23	49
Voted in 1 Contest	0.49	2.17	1.59	0.96
N	200	138	306	644

Table 6 breaks down the under and overvotes by office in the primary election. We see that the Democratic gubernatorial contest had the largest number of overvotes. This is due to the confusing instruction on the top of the ballot that says, "Governor and Lieutenant Governor Vote for One". Under the "Interesting Ballots" menu item we have placed a tab that allows a user to examine these overvoted ballots.

The data also show us that the office of County Judge, which is an approve or disapprove measure, has the largest number (7,307) of undervotes in one of the few county-wide contests. Obviously, voters have little interest or knowledge for this ballot item. The largest percentage (12.5%) was for the Democratic Commissioner of Agriculture, which was somewhat surprising given this is a statewide office. However, this race ended somewhat in scandal, which may be the reason for the high undervote rate.

The female candidate in the contest was Naomi Esther Blemur a black entrepreneur and a member of the Miami-Dade Democratic Executive Committee.[10] Jacques Gaillot had run for office before, but in both his election bids failed. Ryan Morales was a business consultant and hemp farmer. Little was known about any of the candidates, but during the election social media posts from Naomi Blemur revealed that she was very religious and believed abortion was a sin and made what appeared to be homophobic posts as well.[11] This led to several prominent Democrats rescinding their endorsements including Miami Mayor Daniella Levine Cava, State Sen. Annette Taddeo and State Sen Shevrin Jones. Nevertheless, the female candidate won. It would be unlikely for Democratic primary voters to support a prolife or openly homophobic candidate; perhaps this last-minute confusion led many voters to just skip this contest.

Table 6. Frequency of Overvotes and Undervotes in the Primary

Contest	Over-votes	Under-votes	Voter N	% Overvotes	% Undervotes
Senate	2	1492	41,226	0.005	3.62
Governor	20	472	41,226	0.05	1.14
Attorney General (Dem)	2	3,397	41,226	0.005	8.24
Comm. of Agriculture (GOP)	1	1,035	19,297	0.005	5.36
Comm. of Agriculture (Dem)	5	5,166	41,226	0.012	12.53
State 8th House District (Dem)	1	707	14,808	0.007	4.77
County Judge	3	7,307	66,871	0.004	10.92
County Commission At Large	14	4,863	66,871	0.021	7.27
County Commission District 1	0	220	7,573	0.000	2.91
County Commission District 2	4	209	5,772	0.069	3.62
County Commission District 3	0	906	15,363	0.000	5.90
County Commission District 5	2	1,049	18,684	0.011	5.61
School Board District 1	1	1,596	19,600	0.005	8.14
School Board District 4	2	911	17,075	0.012	5.34
Mayor	1	782	39,026	0.003	2.00
City Commissioner Seat 3	3	1,390	39,026	0.008	3.56
City Commissioner Seat 5	3	2,636	39,026	0.008	6.75

We are continuing to examine the data especially the general election, which we received more recently, for additional information.

[10] See Lemongello, Steve, Jeffrey Schweers, Leslie Postal, Stephen Hudak, Martin E. Comas, Ryan Gillespie, Monivette Cordeiro, Annie Martin and Agigail Hasbrook. 2022. Meet the Democratic Candidates Running in the August 23 Primary," *Orlando Sentinel*, August 14, 2022, available at: https://www.orlandosentinel.com/2022/08/27/meet-the-candidates-in-the-florida-primary-election-tuesday/

[11] See Schweers, Jeffrey. 2022. "GOP runs the table with Cabinet races," Transparency USA, available at: https://www.transparencyusa.org/fl/race/attorney-general-of-florida.

Project Obstacles

As part of our dashboard development, we encountered a number of problems. One is the size of the data sets we are building, especially the ballot image data. These items create problems with speed and consequently, useability. We discussed this issue in our making a dashboard section above.

As part of our dashboard, we also present copies of the ballot images so that they are available for public review. However, before we could present the ballot images, we had to resolve a number of different ballot obstacles here as well.

Ballot Orientation

The first problem we encountered was ballot orientation. There is no correct orientation when county staff insert ballots into the audit tabulator. The tabulator can read ballots regardless of the orientation. They can be inserted with either the front or back of the ballot facing up, and the top or bottom of the ballot can be inserted first. That creates 4 possible ballot orientations. These include front-top, which is the orientation we want presented in our dashboard and the other 3 ways, which are upside down (back-top or back-bottom) or flipped (front-bottom). Therefore, to make the ballots presentable to the public, we had to identify the ballot orientation and then flip, turn, or flip and turn the ballot images so they would be displayed in the correct direction.

Identifying and correcting the ballot orientation was done using Python's OpenCV image library. In essence, the bottom-left corner of the ballot was isolated and analyzed. If this region of the ballot contained any shape that had an area less than 5000 pixels, the ballot was considered upside down (bottom ballot), and therefore was flipped. If the bottom-left corner of the ballot contained a shape greater than 5000 pixels, the ballot was considered right-side up (top ballot). On a top ballot, the bottom-left and top-right corner both contain two similar boxes. However, the box on the top-right corner is significantly smaller in area than the box on the bottom-left corner. For a ballot that is upside down, this significantly smaller box would appear on the bottom-left rather than the top-right. This method identified if the smaller box is on the bottom-left or top-right of the ballot. Based on this, the ballot was reorientated.

The 5000-pixel heuristic was determined by surveying 1000 ballots, which included all three ballot types: "ED," "EV," and "VBM," and calculating the max, min, avg, and median area in the Region of Interest (ROI) for all top ballots (right-side up) and bottom ballots (upside-down). Table 1 shows the statistics for this survey.

If jurisdictions do not have access to this technology the low-tech solution is to orient the ballots in the correct direction as they are processed into the audit tabulator.

Table 1. Ballot Survey Statistics

Top-Max	7519.5
Top-Min	6802.0
Top-Avg	7290.778538812785
Top-Median	7293.5
Bot-Max	3182.5
Bot-Min	0.0
Bot-Avg	723.1896551724138
Bot-Median	664.0

Ballot Privacy

Today the secret ballot is considered a fundamental aspect of a democratic election system meant to protect voters from fear of intimidation and is essential to the value of election integrity.[12] Ballot secrecy is guaranteed across the country in state constitutions. Ballot privacy, however, is somewhat at risk when we place election outcome data online with ballot images. For example, in many jurisdictions aggregated vote totals are available from the county cavass by precinct or by precinct and vote mode and these data are often downloadable from county and state election websites. In primary elections, this might also be broken down further by party ballots. In the 2022 Leon County primary election ballots were broken down by vote mode, party ballot, and precinct, potentially creating small cells of voters within combined categories.

To protect voter privacy, states often have arbitrary reporting laws that specify when precinct information needs to be hidden. Florida has a 30-voter threshold for reporting ballot type or precinct data.[13] We followed this rule, which resulted in a number of problems for placing the ballot images online, especially for the primary. The problem stems from the fact that the ballot image contains information about both its precinct and vote mode and, in the case of the primary election, party. First, there is the printed tag in the upper right-hand corner that indicates the precinct (see Figure 4 for 2 ballot examples), which is the four-digit number, which also indicates the party with X (Democrat), Y(Republican), or Z(nonpartisan). Second, there are tick marks at the bottom of the ballot. These also provide information on party, precinct, and language. Finally, combinations of ballot contests as they appear on the ballot can also be used to identify the voting precinct. While Florida does not include information about ballot language preferences in the voter registration file some states do, which given the very few number of non-English ballots here would have triggered a privacy issue in such venues.

The ballot ID information led to substantial problems for maintaining voter privacy, particularly in the primary because we had to not only consider what data we were providing in our

[12] Thomas M. Franck, 1992, "The Emerging Right to Democratic Governance," *The American Journal of International Law*, pp 46-91.
[13] See State Statute 98.09812a available at:
http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&URL=0000-0099/0098/0098.html

dashboard and ballot images, but what data from the state and local canvass could be used to triangulate enough information to identify a voter, his or her ballot, and consequently his or her vote choices. Leon County is a predominantly Democratic County and as such there were few Republican or nonparty voters. When ballots could be categorized by mode, precinct, and party we found that more than half of precincts did not meet the 30-ballot statute requirement.

To resolve these privacy issues for the primary and comply with state law, we removed precinct and party information in the upper righthand corner of the ballot, the tick marks at the bottom of the ballot, and disabled the Leon County precinct map. Finally, we had to withhold 43 ballots because the unique contest combinations on these ballots could reveal individual vote choices and violate voter privacy and state law.

In the general election with more voters and no party ballots to distinguish sets of voters, the problems were not as severe. Of 135 precincts, 21 had thirty or fewer voters for at least one vote mode. One additional precinct had more than 30 voters, but every Early-Voting voter voted for Crist, and every Vote-by-Mail voter voted for Demings. We needed another eight precincts combined with these small precincts for the redaction to work. This led us to 30 precincts that required us to remove the precinct numbers and barcodes. A total of 4,422 ballots out of 118,216 ballots were affected.

In addition, we had to be concerned with voters self-identifying by printing or signing their name on their ballot. Therefore, we had to develop methods to identify and redact personal identifiers.

Ballot Redaction Methodology

To maintain voter privacy, the following items had to be redacted from every primary ballot. For the front side of ballots this included:

1. Precinct and party information in the upper right-hand corner;
2. Tick marks at the bottom of the ballot.
3. For “EV” ballots, the “Checkin EV” tag was removed.

For the back side of ballots this included:

1. Precinct and party information on the center of the ballot;
2. Tick marks at the bottom of the ballot.
3. For “EV” ballots the “EV” tag was removed.
4. For “VBM” ballots the QR code and precinct number next to it were removed.

Ballot Redaction Precinct Information

To redact precinct and party information in the upper-right hand corner for the primary and precinct information for a relatively small number of ballots in the general election, a region at the top right of the ballot region of interest (ROI) was cropped for further analysis. Further analysis included:

1. Identifying shapes and contours in the ROI;
2. Getting the contour with the greatest area, call it best_contour;

3. Extracting the top-left point of the best_contour (x, y)

With the x and y value extracted from the contour with the largest area, we determined there was a fixed distance in pixels from this contour to the precinct information that had to be redacted. We then calculated the location of the precinct information by adding the x and y values of the contour start point determined earlier with a fixed distance. This returns the starting point of the area that needs to be redacted. We then do a similar process to determine where the end of the redaction location is. A similar method was employed to redact the bars on the bottom-left corner of the ballot, and the "Checkin EV" tag on the bottom-right side of the ballot.

This method must be employed because there are relatively large variations between ballots in the y-position where the precinct information resides, so the redaction location must be dynamically calculated. For example, in some cases the top left point where the precinct information resides was at (1240, 210) and other ballots it occurred at (1260, 180). Therefore, it was crucial to dynamically calculate redaction position to keep other aspects of the ballot intact.

For the back side of ballots, redacting the bars and the "Checkin EV" tag was identical to that of the front side. However, the precinct information was displayed in a different region than on the front side. Luckily, it was located in a relatively unimportant region of the ballot. Because of this, we was able to redact a large fixed region of the ballot that covered anywhere the precinct information could occur. This was also true for the QR code on the "VBM" ballots.

Running redaction operation on all ballot

Because we are working with a large number of ballots, speed was an issue. Fortunately, this task is a perfect candidate for Python's threading library, specifically because there is a large number of files to write. Threading was employed by equally splitting up the list of ballots to redact into 11 different sets. Eleven threads were started and each was fed one of these sets. With no threading, running through a sample set of approximately 700 ballots took around 26 seconds. With threading, it took less than 3.5 seconds.

Converting back to PDF

It was also required that these images be converted back to PDFs. This was achieved using python's Pillow library.

Signature Identification

For the primary election, each ballot was manually examined by human eyes for voter names or signatures. However, in the general election, due to the sheer number of ballots, manual signature identification was not an option.

We used a machine learning model to autonomously identify signatures on ballots. The best way to do this is to use a pretrained model which already has many of the necessary weights and biases to properly label images. Using a pretrained model lowers the total required training time and reduces the amount of data required to train the model.

We used the You Only Look Once version 8 (YOLOv8) medium sized model.
To train the model, we collected signature and other voter writing data from ballots identified in the primaries. We supplemented these data with two signature datasets for a total of 138 signatures.

We randomly selected 1,500 general election ballots for a starter data set. We manually looked at these ballots to ensure there was no voter writing already on them. We set aside 20 percent of the ballot dataset to have no signatures on them. This was done to reduce the number of false positives produced by the model. The signatures were then placed semi-randomly on each ballot and augmented to create more variation between signatures.

The ballots, with signatures, were then split into two different data sets: a training set (80 percent of total ballots) and a validation set (20 percent of total ballots).

The Machine Learning Model

There were three main iterations of the model that contributed to the final set of identified ballots. Model 1's dataset was largely created by following the procedure outlined in Data Creation. Model 1 and 2 were trained for 75 epochs, then stopped. YOLOv8 was then told to treat the last checkpoint as a pretrained model, this resets various model parameters, most notably, learning rate. It was observed that doing this in earlier trial runs of model's produced much better results. Model iteration 2 and 3 were trained off additional true and false positives obtained from running model 1 through the entire general election set and categorizing its labels.

A comparable model was developed for the primary election ballots to validate the methodology's results and performed very well.

Impact

This is an important pilot project that placed postelection audit data and ballot images online for public review. Our project provides important insights and valuable information for election administrators considering displays of their postelection audits, election results, and ballot images.

We faced quite a number of obstacles along the way that election administrators would likely have to deal with, especially if they decided to put ballot images online. The size of the data sets we created were large and we had to find software to manage them so it would have a good user interface. Problems around voter privacy especially in the primary were ubiquitous. Data triangulation from the state and county canvass, the voter file, and the ballot data created potential privacy concerns. Ballot tick marks, contest arrangements on the ballots (i.e. ballot styles), and ballot IDs are all distinct ways to identify ballots and provide potential avenues to determine voter choices.

We also found that a small, but not insignificant number of voters printed or signed their name directly on the ballot, also creating voter privacy problems. Given the possibility of vote buying

and laws about voter privacy and ballot secrecy, our project identifies the scope of the problem and outlines possible solutions, including technological solutions on the back end and policy solutions on the front end.

In addition, we gained valuable pieces of descriptive information during the project about how voters interact with their ballots and how they use their ballots as an expressive tool. On our website, we included several interesting ballot buckets for voters to review. These include ballots with no votes, ballots with signatures, other interesting ballots with marks, and ballots with overvotes for the gubernatorial primary, which has poor directions creating confusion for a small set of voters.