Demonstration of “Open Counting”: A Paper-Assisted Voting System with Public OMR-At-A-Distance Counting

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Abstract

Although research and development work on better voting schemes and processes has increased since the 2000 US Presidential Election in the USA, voter confidence in new technologies such as electronic voting has actually declined. One reason for this decline can be found in the vote-counting process: While electronic voting can indeed produce more accurate results more quickly than traditional approaches, it does so at the price of further reducing the transparency of vote counting to the public. In previous work we presented a simple paper-based public vote-counting method which can be used to improve transparency and accuracy. In this work we present a simple working prototype.

1. Introduction

Ever since the invention of the Australian Paper Ballot, improvements have been proposed to provide faster, less labor-intensive results. Systems which record votes electronically, or on optically-scanned ballots have become popular. Each of these systems has promised a speedup and labor-reduction when tallying the results. However each of these systems, by the very nature of their automation, seem to have reduced counting transparency and seem to consistently have less integrity when compared to the pure Australian Paper Ballot scheme. Thus, to ensure voter confidence, many countries still rely on the Australian Paper Ballot system. A casual observer may conclude that there must always be a trade-off between transparency and speed. Below we propose a system that we believe provides a good compromise and achieves both transparency and speed.

2. Totally Public Counting using OMR-at-a-Distance

The counting in our scheme uses paper ballots that are counted publicly with what we call OMR-At A-Distance. Since it's done in public we call this scheme Public OMR-at-a-Distance or POMRAD. We described POMRAD in an earlier publication (4) and it was originally explored as “Open Counting” in (5). For completeness we present a quick overview below.

POMRAD can be inserted into the standard Australian Paper Ballot scheme to produce what we believe is a voting scheme with desirable qualities. We describe such a modified Australian Paper Ballot scheme below.

We describe this scheme as having two steps; voting and counting.

2.1 Voting

Voting proceeds as it would in a typical Australian paper ballot scheme. Each voter must go to a polling station. At the polling station, the voter marks their choices on a paper ballot. The format of each ballot follows an open standard that is optimized for usability and Public OMR-at-a-distance. All known precautions that can

be undertaken to prevent error and fraud in an Australian paper ballot system can be applied here to the paper ballot and polling station. In particular, ballots can be deposited in a publicly observed and preferably transparent ballot box. Numbered stubs can be used to help prevent chain voting and secrecy envelopes can be used to guard privacy and anonymity.

2.2 Counting

As in the Australian paper ballot system, the counting is performed by the voting judges. These judges administer and monitor the voting process. After the voting has finished, one or two of these judges is designated to display the ballots using a simple tool (such as a page feeder) and the rest of the judges are designated to operate their own counting hardware that video-records and analyses this display. The video-recording can be done with commodity camcorders and the analysis can be done using standard computer vision algorithms run on commodity PC's. The ballots are displayed and each judge periodically announces their tally of the votes. If there is a disagreement among the judges, the ballot in question can be displayed so as to resolve the dispute. This process is completely open to observers who may tally the votes through the public display themselves; using their own camcorders and commodity PC's. During the counting all judges must publish the hash key of their recorded video using a secure hash function, such as SHA-1. Observers may chose to do the same if they wish to give their own video recording more credibility. This hash code can later be used to verify the video during a possible audit of the automated counting process.

3. Analysis of the Modified Australian Scheme

Our analysis relative to accuracy, integrity engendering voter-confidence and feasibility of POMRAD is very promising.

3.1 Accuracy and Integrity

Transparency is maintained as much as possible at all times. Each action of a judge can be monitored by the other judges. These other judges can in-turn intervene and recheck the original ballot if there is a dispute. Moreover all the judges' actions can be monitored by outside observers who may file grievances at a later time. Election judges can witness and prevent any possible modification or miscounting of a ballot. Observers can detect and possibly report such errors. This level of transparency and redundancy is arguably as high if not higher than that established even by the Australian paper ballot system.

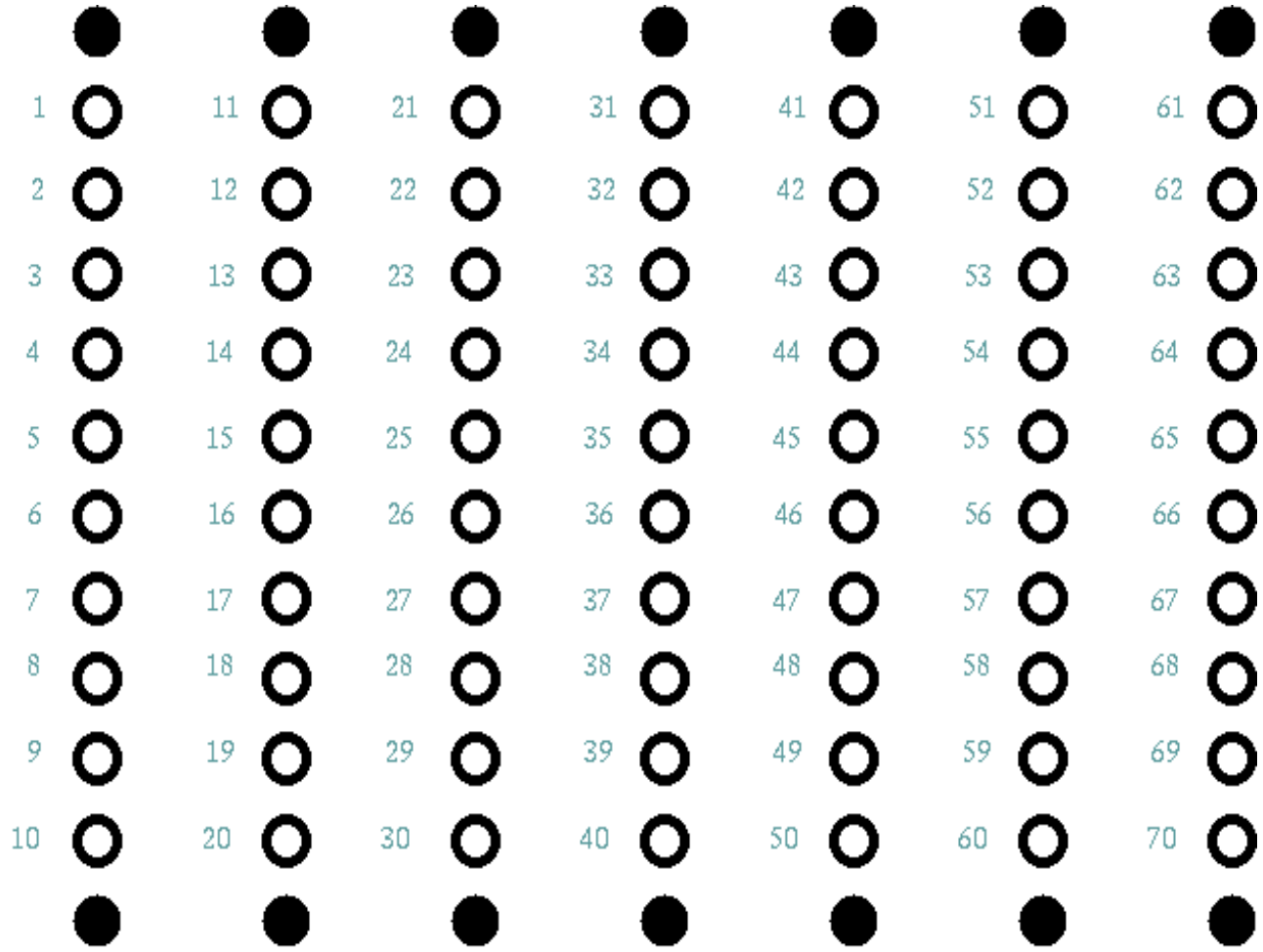
3.2 Engendering Voter Confidence

Due to the potential combination of speed and transparency, this new scheme may engender more voter confidence than before. The entire process can be done at the polling station in view of anyone that chooses to be there. In the past, punch cards have required the ballots to be transported to a centralized precinct for tabulation by heavy and heavily specialized machines that required certification and maintenance. Even some current OMR systems require the use of specialized hardware and thus have required the ballots to be transported to the precinct and for the machines to be certified and maintained. Ballot stuffing has been more commonly reported while the ballots were en-route to the precinct. Transportation of ballots can be long and it can limit the number of observers monitoring the ballot box. With this new scheme, a simple count can be done quickly and transparently at the polling station. There is no need for specialized hardware nor the transportation of uncounted ballots. This arguably eliminates two major obstacles to voter

confidence.

4 A Working Prototype

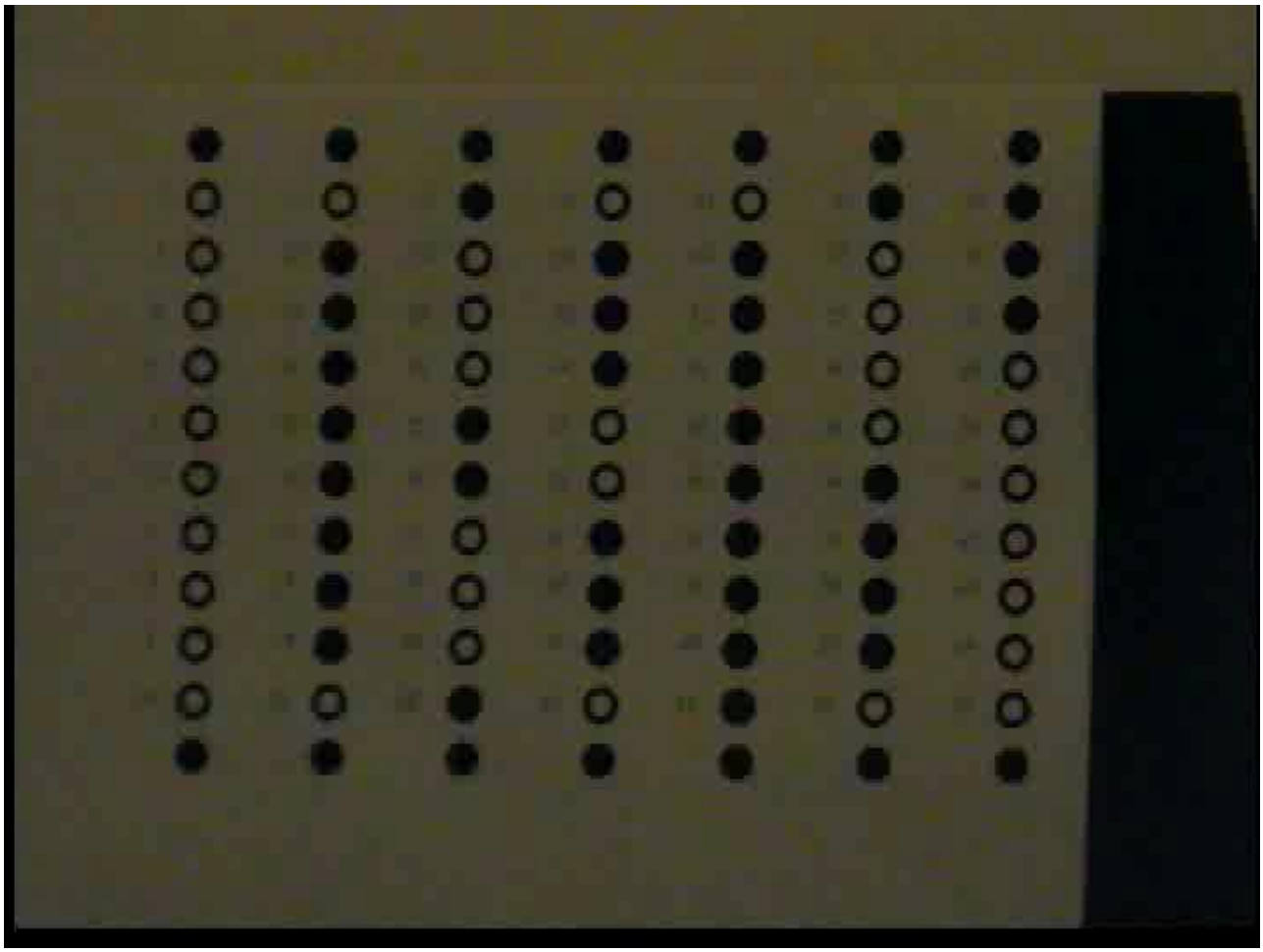
We implemented a prototype of POMRAD using software-only computer vision algorithms and a cheap camcorder. The ballots are simple numbered bubbles similar to what one may find on an standardized test. The only difference is that the ballot has extra spacing and some marks to ease at-a-distance pattern recognition. An example ballot is shown below.



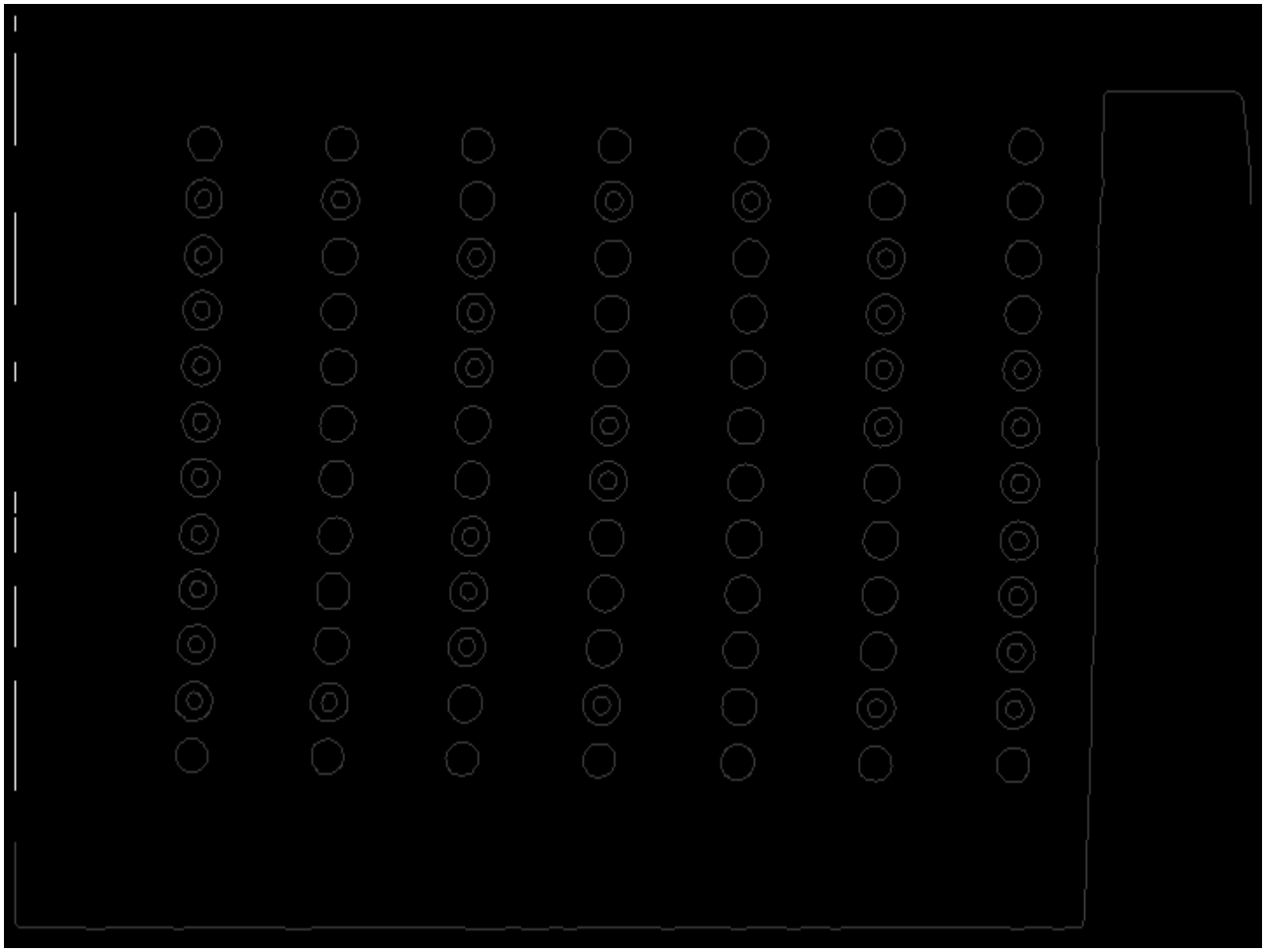
One note here is that just like the Australian paper ballot scheme, disabled voters may use automated vote-marking technology to mark their paper ballot. All other voters are instructed to mark the ballot by using a “sharpie” pen which is much darker and larger than a usual pencil or pen. The first and last row of circles are filled when the ballot is printed in order to ease the image analysis later.

The ballots are then simply photographed from a distance using the camcorder. A real-world situation is simulated by not using any special lighting and using a very cheap camcorder. The camcorder setup we use costs less than $300. The camcorder has a resolution of 720X480 and includes a 34X optical zoom lens. The display

apparatus uses a printer with a form-feed button which is used to flip through the ballots at a steady rate of approximately 1 ballot every 2 seconds. White cardboard paper provides a white background. The video produced by the camcorder is examined by the naked eye and one frame per ballot is taken from the video to be used for image analysis on a laptop.



Basic edge detection is then applied to each picture. To tune the edge-detection algorithm it is first run 10 times at various sensitivities. Signal-to-noise ratio analysis is used to find the best setting to be used for all other subsequent image analyses. This auto-tuning operation takes about 1 second while each subsequent image analysis takes about 0.2 seconds per frame. We are operating on a Pentium 4 laptop running Debian Linux at 4600.07 bogomips with 500MB of RAM. An example of applying the edge detection is shown below:



After the automated tuning and finding the edges, the analysis algorithm looks for the filled-in rows of bubbles at the top and bottom of the image. Then, the bubbles between the top and bottom rows are analyzed for a user mark.

4.1 Work still needed to be done

We are still refining our prototype. As for the image analysis, by using simple heuristics like the aspect ratio of the connected components found, sorting them by size and optimization of the signal-to-noise ratio we believe the whole process can be automated to require very little tuning. We also believe that the human-aided step of picking out the frames from the video to be used for analysis can be automated by motion detection. In the future we hope to be able to simply give our algorithm a video and without any tuning, it should be able to produce a vote count. The possibility that a lay person would be able to run a program based on this prototype seems quite likely. There is also the issue of trying to have POMRAD work for ballots which include a full description of the choice along with each bubble. Having the voter's choice printed on the ballot has some advantages. It would prevent fraud and confusion which could ensue due to the layer of indirection introduced by the numbered bubbles. Accommodating such ballots seems to be feasible, but it also seems to require a little more engineering. Finally, it

should be noted that we have not done any large-scale tests to measure the accuracy of this prototype implementation.

5. Conclusion

Joseph Stalin is reported to have said ``Those who cast the votes decide nothing. Those who count the votes decide everything.'' In designing our new scheme we have tried to re-expand the class of ``those who count the votes'' directly back to the voters through redundant transparency. Our new scheme also promises the speed of a paperless automated system. Recent studies show that voter confidence has plummeted(in the USA) since the introduction of electronic voting and counting machines. We hope this prototype is a step towards realizing truly open, yet fast counting. It is hoped that an adoption of this voting scheme or one similar to it may help boost voter confidence due to their ability to actually see the votes being counted. Although a full implementation is still not complete and further testing is required, we may have a voting scheme that harmoniously combines simplicity and transparency with speed and privacy.

Acknowledgments

The original idea for POMRAD was generated and developed in a discussion held at the online forums at blackboxvoting.org. This discussion is archived at (6). We would like to thank the many volunteers at blackboxvoting.org who participated in this discussion. We thank Bev Harris in particular for her inspiration, encouragement and critiques.

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