Voting Technology: The Not-So-Simple Act of Casting a Ballot

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Voting Systems: A Balancing Act

How to make engineering decisions?
Balance requirements

- Accessibility
- Accuracy
- Complexity
- Cost
- Reliability
- Security
- Security Perception
- Size
- Speed
- Usability

Our focus
Known Usability Problems: Hanging Chad

- Hanging chad

[Florida 2000]

Known Usability Problems: Butterfly Ballot

- Confusing alignment

[Florida 2000]
Known Usability Problems: Optical Scan Write-in

- Write-in requires bubble
- Frye claims to have lost 4-5,000 votes
- Murphy won mayoral race by 2,205 votes
- Murphy resigned 5 months later

[San Diego 2004]

Known Usability Problems: Missed Race

- Banner blindness
- Consistency
- 18,000 votes “lost”

[Sarasota 2006]
So we did a study

- Expert review (10 experts)
- Field study (1,500 participants in 3 states)
- Lab study (42 participants)

Looked at:
- Accuracy
- Preference

On:
- 6 voting machines
- 4 verification systems

ES&S Model 100

- Paper ballot/optical scan
- Intake similar to a fax machine
- Warnings for overvotes
- No warning for undervotes
- Can cast a flawed ballot
Diebold AccuVote-TS

- Touch screen
- Smart card activation
- Manual navigation
- Ballot review
- Impossible to overvote
- Highlights undervotes

Avante Vote Trakker

- Touch screen
- Automatic advance navigation
- Paper printout for verification
- Impossible to overvote
- Highlights undervotes
Zoomable Prototype

- Zooming navigation
- Overview of full ballot
- Voting decisions replace names of offices
- Impossible to overvote
- Highlights undervotes
- Developed at the University of Maryland

Hart InterCivic eSlate

- Mechanical buttons and dial for navigation and candidate selection
- Impossible to overvote
- Highlights undervotes
Nedap LibertyVote

- Full-face voting system
- Membrane buttons to select candidates
- Blue lights indicate selections
- Impossible to overvote
- Warning for undervotes

Experimental Setup

Tasks:
- 18 offices & 4 ballot questions
- Office block & Straight party
- Multi-candidate election
- Change a vote
- Cast a write-in vote

Process:
- Pre-mark booklet
- Write-in matched voter with booklet
### Accuracy – Vote for President

<table>
<thead>
<tr>
<th>Percent of votes</th>
<th>ES&amp;S Model 100</th>
<th>Diebold AccuVote TS</th>
<th>Avante Vote-Trakker</th>
<th>Zoomable Prototype</th>
<th>Hart InterCivic eSlate</th>
<th>Nedap Liberty Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voted as intended</td>
<td>95.8</td>
<td>96.7</td>
<td>96.7</td>
<td>97.5</td>
<td>96.3</td>
<td>96.3</td>
</tr>
<tr>
<td>Proximity error</td>
<td>3.0</td>
<td>2.4</td>
<td>2.2</td>
<td>1.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Voted for another candidate</td>
<td>1.0</td>
<td>0.4</td>
<td>1.0</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>No vote cast</td>
<td>0.2</td>
<td>0.5</td>
<td>0.1</td>
<td>0.6</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

### Accuracy – Impact of Task

<table>
<thead>
<tr>
<th>Task</th>
<th>ES&amp;S Model 100</th>
<th>Diebold AccuVote TS</th>
<th>Avante Vote-Trakker</th>
<th>Zoomable Prototype</th>
<th>Hart InterCivic eSlate</th>
<th>Nedap Liberty Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>No special tasks</td>
<td>97.4</td>
<td>97.7</td>
<td>97.5</td>
<td>97.6</td>
<td>97.1</td>
<td>97.5</td>
</tr>
<tr>
<td>Vote for two</td>
<td>96.5</td>
<td>95.7</td>
<td>93.5</td>
<td>96.6</td>
<td>86.6</td>
<td>94.6</td>
</tr>
<tr>
<td>Change vote</td>
<td>89.6</td>
<td>93.9</td>
<td>85.6</td>
<td>92.8</td>
<td>92.0</td>
<td>90.7</td>
</tr>
</tbody>
</table>
### Accuracy – Write-In Errors

<table>
<thead>
<tr>
<th>Percent of ballots</th>
<th>ES&amp;S Model 100</th>
<th>Diebold AccuVote TS</th>
<th>Avante Vote-Trakker</th>
<th>Zoomable Prototype</th>
<th>Hart InterCivic eSlate</th>
<th>Nedap Liberty Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfect</td>
<td>70.2</td>
<td>90.7</td>
<td>92.2</td>
<td>89.3</td>
<td>86.2</td>
<td>88.2</td>
</tr>
<tr>
<td>Error writing name</td>
<td>1.7</td>
<td>6.3</td>
<td>4.3</td>
<td>8.1</td>
<td>10.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Unlikely to be counted</td>
<td>28.1</td>
<td>3.0</td>
<td>3.5</td>
<td>2.6</td>
<td>3.2</td>
<td>3.7</td>
</tr>
<tr>
<td>No vote cast</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
<td>1.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Other cand.</td>
<td>2.0</td>
<td>1.7</td>
<td>2.4</td>
<td>1.4</td>
<td>1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>No Bubble</td>
<td>25.0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Satisfaction - Overall

![Satisfaction Chart](chart.png)
Satisfaction – By Kind

- Inspires confidence
- Easy to use
- Easy to correct mistake
- Easy to cast write-in

- ES&S
- Diebold
- Avante
- Zoomable
- Hart
- Nedap

Satisfaction – By Voter Type

- Alana – Young white female (master’s)
- Jesse – Older African American male (high school)
Percent Requesting Help

- **Alana** – Young white female (master’s)
- **Jesse** – Older African American male (high school)

Specific Problems

- Hard to correct mistakes
- Paper did not give enough feedback
- Automatic advance problematic
- Non-touch screen display confusing
- Full screen problematic
- Review screen problematic
- Paper trail ignored or frustrated
Verification Study

- Test the usability of four vote verification systems
- Requested by Maryland SBE
- Review by HCI experts
- Field experiments with approximately 800 participants

Diebold AccuVote-TSx with AccuView Printer Module

- Paper printout
- After-the-fact verification
- No independent verification unit
- Magnifying glass
- Privacy cover
- Two chances to review prior to casting ballot
- Ballots not randomly stored (privacy issues)
- Bar code can be scanned for recount
VoteHere Sentinel

- Cryptography
  - Very complicated
- After-the-fact verification
- Independent verification unit
- Paper printout
- Simple verification-all
  - Was ballot counted?
- Advanced verification-500
  - Were individual votes accurately cast?
- Ballots randomly stored
- Compare computerized vote totals to voting system

Scytl Pnyx

- Small computer monitor
- After-the-fact verification
- Independent verification unit
- Voters review elections race by race
- Can change ballot on system and cast vote
- Ballots randomly stored
- Compare computerized vote totals to totals on voting system
MIT Prototype

- Audio
- Recorder/headphones
- Analog tape
- Simultaneous verification
- Independent verification unit
- Ballots not randomly stored (privacy issue)
- Tape can be played for recount

Diebold AccuVote-TS

- No verification unit
- Used in Maryland & other states & localities
- Control system in field experiment
Voting Tasks

- Vote for 5 offices
- Change a vote
- Vote for two candidates
- Cast a write-in vote

Voter Satisfaction
Need For Help

Verification Systems Summary

- All fairly positive
- Tradeoffs between usability & verification
- Tradeoffs between actual and perceived security (cryptographic vs. paper trail)
- After-the-fact preferable to simultaneous
Conclusions

- Vote verification systems decrease usability of voting systems
  - Does not increase satisfaction
  - Increases need for help

- No significant differences in voters’ evaluations of paper receipt, system with no verification unit, and cryptographic system

Recommendations

- Usability must be considered in acquisition
- Simple and fewest actions good
- Avoid straight-party device
- Avoid overwhelming voter with too much info
- Review should show undervote
- Verification systems should be considered cautiously
Usability vs. Security?

Usability AND Security – My Opinion

Alternative Solutions:
- Open source & secured touch screen system
- Run by public not-for-profit corporation

Or:
- Touch screen EBM (also counts)
- Optical scan printout for the record
- Centralized optical scan reader
- Discrepancy with TS causes recount

Or:
- Same as above but with reader per precinct
  - Enhances speed at which discrepancies are caught
  - Improves clarity of process
Usability AND Security – My Opinion

But:

- Paper not a panacea
  (Lyndon Johnson’s first election to Senate made possible by missing ballot box…)
- Security perception not a broad problem
- Paper fraud has lower technical barrier

Summary

- That press release ...
- I think voter trust *is* important
- I think voting usability should be equal to security in USACM’s communications
- Consider building our own ...
For More Information

www.cs.umd.edu/~bederson/voting
www.capc.umd.edu

NSF #0306698
Carnegie Corporation #D05008
Maryland SBE

Thank you!