

# The Decisive Power of Indecision: Low-Variance Risk-Limiting Audits and Election Contestation via Marginal Mark Recording



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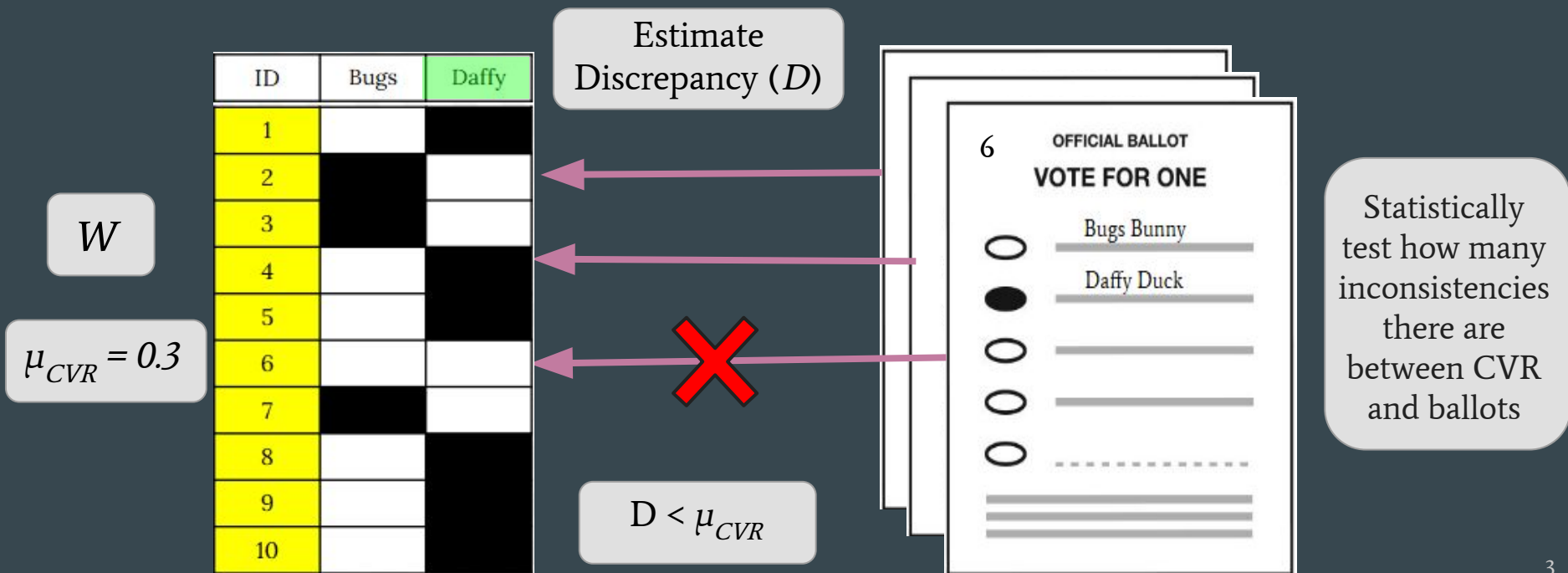
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# Introduction

Risk Limiting Audits (RLAs): A procedure used to verify the outcome of an election by re-examining cast ballots and their corresponding CVR row.



# Drawbacks of RLAs

Efficiency Concerns: Large # sampled ballots



More discrepancies between CVR and Ballot = Lower public confidence  
in audit/election

# Our Approaches & Benefits

## Conservative / Marginal Prediction Approach

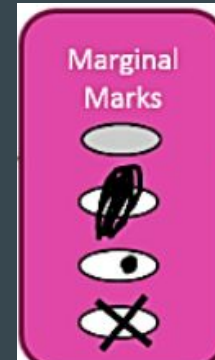
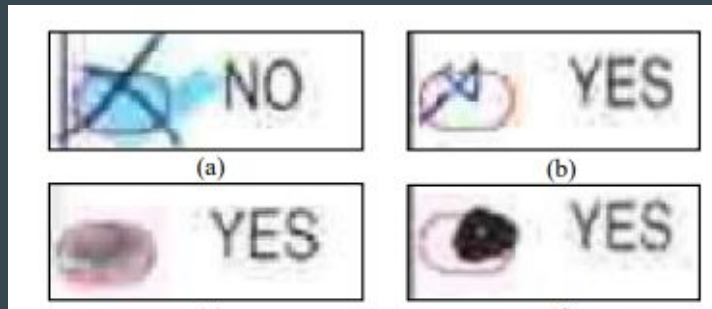
- More discrepancies = Lower public confidence
  - Helps with public perception and interpretability
- Large # sampled ballots
  - Reduction in sample size during an RLA  $\Rightarrow$  improves efficiency

## Competitive Audits

- Provides an efficient contestation mechanism with the RLA system.
- Puts majority of the work on the party that is contesting the audit

# Marginal Marks

Marginal Marks: Marks on ballots where voter intent is unclear.



- In practice, these marks result in consistency failures in conventional audits
- Discrepancies due to these marks  $\Rightarrow$  expensive + more ballots pulled

# Baseline CVR

- We discuss two new approaches:  
Conservative and Marginal  
Prediction Approaches
- Redefine Baseline CVR semantics
- Explicit indications of marginal  
marks

ID	Bugs	Daffy
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

# Conservative Approach

ID	Bugs	Daffy	No Vote
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

No Vote Column reflects **no-mark** and **overvote** cases

- Declares set of interpretations for marginally marked ballots in a CVR



# Marginal Prediction Approach

- Records a prediction probability distribution of possible interpretations

ID	Bugs	Daffy	No Vote
1	1		
2	.72	.02	.26
3	.99		.01
4		1	
5		.75	.25
6	.12	.38	.5
7	.46	.1	.44
8		1	
9		1	
10		.02	.98

Blank Cells = 0% Probability

# Simulation Parameters

- Two candidate election
- 100,000 ballots (large enough to prevent drawing the same ballot multiple times)
- 0.5% Marginal Ballots
- $o_1 = 0.1\%$ ,  $o_2 = 0.01\%$  (overvote rates)
- $u_1 = 0.1\%$ ,  $u_2 = 0.01\%$  (undervote rates)
- Marginal Ballots → assume 2 possible interpretations:
  - Interpretation for the winner  $W$  (*Discrepancy = 0*)
  - Interpretation of an undervote (*Discrepancy = 1*)
- Ran the Kaplan Markov Test to determine # of sampled ballots

# Simulation Results

$\mu$	Baseline			Conservative			Marginal Prediction		
	Mean	Median	95%	Mean	Median	95%	Mean	Median	95%
.01	608	567	1028	595	576	938	583	545	920
.02	316	292	469	314	294	420	308	292	415
.03	213	202	283	212	219	263	210	202	271

Ballots sampled  
reduced by around  
10.5% → margins of  
1%

# Competitive Audits Overview

Main Idea: Addresses challenges in election outcomes

- Alternative groups (“advocates”) can submit their own competing CVR.
- Advocates can choose an interpretation for marginally marked ballots
- Advocates can choose to omit sampled ballots from their CVR
- For simplicity, we focus on the conservative case

General Framework: Compare and disqualify contradictory advocate CVR pairs until a single CVR is left, or output *Inconclusive*.

# Practical Considerations of Methods

## Conservative / Marginal Prediction Approach

- Explicit marginal marks – helps with public perception and interpretability
- Conservative audits are simpler
  - Set of interpretations vs likelihood estimate
- Only firmware upgrades required for conservative approach

## Competitive Audits

- Can be implemented as a standalone procedure, or after the RLA process.
- Advocates allowed to inspect the physical ballots under supervision.
- A candidate is determined the winner regardless of the procedure and softwares used by other advocates
- Advocates can use their own tools to process ballot images.