

# An Analysis of Write-in Marks on Optical Scan Ballots

Theron Ji   Eric Kim   Raji Srikantan   Alan Tsai  
Arel Cordero   David Wagner

*UC Berkeley*

# Optical Scan Ballots

**2509G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

• TO VOTE, COMPLETELY FILL IN THE OVAL  NEXT TO YOUR CHOICE.  
• Please use only a blue or black marker or pen.  
• If you make a mistake, don't hesitate to ask for a new ballot. If you erase or make other marks, your vote may not count.  
• To vote for a candidate whose name is not printed on the ballot, fill in the oval, and write in the candidate's name on the blank line provided for a write-in candidate.

PRESIDENT AND VICE PRESIDENT	LEGISLATIVE	DISTRICT COURT OF APPEAL
<b>PRESIDENT AND VICE PRESIDENT</b> (Vote for One)	<b>STATE REPRESENTATIVE</b> <b>8TH HOUSE DISTRICT</b> (Vote for One)	Shall Judge William A. Van Norwick, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO
<input checked="" type="radio"/> John McCain Sarah Palin REP	<input type="radio"/> Alan Williams DEM	<b>CIRCUIT JUDGE, 2ND CIRCUIT</b> <b>GROUP 7</b> (Vote for One)
<input type="radio"/> Barack Obama Joe Biden DEM	<input checked="" type="radio"/> Robert Maddox NPA	<input checked="" type="radio"/> Lisa Raleigh
<input type="radio"/> Gloria La Riva Eugene Puryear PSL	<b>NONPARTISAN JUDICIAL</b>	<input type="radio"/> Frank E. Sheffield
<input type="radio"/> Chuck Baldwin Darrell Casale CPF	<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>COUNTY JUDGE</b> <b>GROUP 5</b> (Vote for One)
<input type="radio"/> Gene Amundson Leroy Pletten PRO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Nina Ashwell Richardson
<input type="radio"/> Bob Barr Wayne A. Root LBT	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input checked="" type="radio"/> Sean Desmond
<input type="radio"/> Thomas Robert Stevens Allen Link OBJ	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Margaret H. Davis of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>NONPARTISAN COUNTY</b>
<input type="radio"/> James Harris Alyson Kennedy SWP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>COUNTY COMMISSIONER</b> <b>AT LARGE, GROUP 1</b> (Vote for One)
<input type="radio"/> Cynthia McKinney Rosa Clemente GRE	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Alvin Akinyemi
<input type="radio"/> Alan Keyes Brian Rohrbaugh AIP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input checked="" type="radio"/> Ed DePuy
<input type="radio"/> Ralph Nader Matt Gonzalez ECO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>MUNICIPAL</b>
<input type="radio"/> Brian Moore Stewart Alexander SPF	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>CITY COMMISSIONER</b> <b>SEAT 1</b> (Vote for One)
<input type="radio"/> Charles Jay John Wayne Smith BTP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Mark Muzian
<input type="radio"/> Write-in	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Write-in <i>Joe Miller</i>
<b>CONGRESSIONAL</b>	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>NONPARTISAN SPECIAL DISTRICT</b>
<b>REPRESENTATIVE IN CONGRESS</b> <b>2ND CONGRESSIONAL DISTRICT</b> (Vote for One)	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION</b> <b>DISTRICT 1 SUPERVISOR</b> (Vote for One)
<input checked="" type="radio"/> Mark Mulligan REP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input checked="" type="radio"/> Brian Acosta
<input type="radio"/> Allen Boyd DEM	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Sean McCaym
<input type="radio"/> Write-in	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	

**VOTE BOTH SIDES OF BALLOT**

FRONT Card 2 Ballot 2509 "2509"

- Widely used in today's elections
- Voters indicate choices by marking voting targets
- Scanner tabulates votes by detecting marks

# Write-ins

**2509G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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**Write-in**

<input type="radio"/> Gene Robinson Leroy Pletten	PRO	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> Bob Barr Wayne A. Root	LBT	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Blethen of the First District Court of Appeal be retained in office?
<input type="radio"/> Thomas Robert Stevens Allen Link	OBJ	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> James Harris Alyson Kennedy	SWP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Margaret H. Davis of the First District Court of Appeal be retained in office?
<input type="radio"/> Cynthia McKinney Rosa Clemente	GRE	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> Alan Keyes Brian Rohrbaugh	AIP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office?
<input type="radio"/> Ralph Nader Matt Gonzalez	ECO	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> Brian Moore Stewart Alexander	SPF	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pabson of the First District Court of Appeal be retained in office?
<input type="radio"/> Charles Jay John Wayne Smith	BTP	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> Write-in		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office?
<b>CONGRESSIONAL</b>		<input type="radio"/> YES <input checked="" type="radio"/> NO
<b>REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)</b>		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office?
<input checked="" type="radio"/> Mark Mulligan	REP	<input type="radio"/> YES <input checked="" type="radio"/> NO
<input type="radio"/> Allen Boyd	DEM	
<input type="radio"/> Write-in		

**NONPARTISAN COUNTY**

**COUNTY COMMISSIONER  
AT LARGE, GROUP 1  
(Vote for One)**

Nina Ashwell Richardson  
 Sean Desmond

**MUNICIPAL**

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Muzian  
 Write-in *Joe Muller*

**NONPARTISAN SPECIAL DISTRICT**

**OCHLOCKNEE RIVER SOIL &  
WATER CONSERVATION  
DISTRICT 1 SUPERVISOR  
(Vote for One)**

Brian Acosta  
 Sean McCaylin

**VOTE BOTH SIDES OF BALLOT**

FRONT Card 2 Ballot 2509 "2509G"

- Region where write-in candidates are written in by the voter

- Corresponding voting target must be filled for vote to count

- So does this happen?

# Motivation

2509G OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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Write-in

<input type="radio"/> Gene Robinson Leroy Pletten	PRO	<input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Nina Ashwell Richardson <input checked="" type="radio"/> Sean Desmond
<input type="radio"/> Bob Barr Wayne A. Root	LBT	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Blethen of the First District Court of Appeal be retained in office?	<b>NONPARTISAN COUNTY</b>
<input type="radio"/> Thomas Robert Stevens Allen Link	OBJ	<input type="radio"/> YES <input checked="" type="radio"/> NO	<b>COUNTY COMMISSIONER AT LARGE, GROUP 1</b> (Vote for One)
<input type="radio"/> James Harris Alyson Kennedy	SWP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Margaret H. Davis of the First District Court of Appeal be retained in office?	<input type="radio"/> Alvin Akinyemi <input checked="" type="radio"/> Ed DePuy
<input type="radio"/> Cynthia McKinney Rosa Clemente	GRE	<input type="radio"/> YES <input checked="" type="radio"/> NO	<b>MUNICIPAL</b>
<input type="radio"/> Alan Keyes Brian Rohrbaugh	AIP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office?	<b>CITY COMMISSIONER SEAT 1</b> (Vote for One)
<input type="radio"/> Ralph Nader Matt Gonzalez	ECO	<input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Mark Muzian Write-in: <i>Joe Miller</i>
<input type="radio"/> Brian Moore Stewart Alexander	SPF	<input type="radio"/> YES <input checked="" type="radio"/> NO	<b>NONPARTISAN SPECIAL DISTRICT</b>
<input type="radio"/> Charles Jay John Wayne Smith	BTP	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Pribben of the First District Court of Appeal be retained in office?	<b>OCHLOCKONEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR</b> (Vote for One)
<input type="radio"/> Write-in		<input type="radio"/> YES <input checked="" type="radio"/> NO	<input checked="" type="radio"/> Brian Accosta <input type="radio"/> Sean McCaylin

**CONGRESSIONAL**

**REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT**  
(Vote for One)

Mark Mulligan  
 Allen Boyd  
 Write-in

REP  
DEM

**DISTRICT COURT OF APPEAL**  
Shall Judge Clay Roberts of the First District Court of Appeal be retained in office?

YES  
 NO

VOTE BOTH SIDES OF BALLOT

FRONT Card 2 Ballot 2509 2509G

- Lisa Murkowski **wins** the 2010 Alaska Senate election through a write-in campaign

- Donna Frye narrowly **loses** the 2004 San Diego mayoral election because people forgot to mark the write-in voting target

# Problem

**CITY COMMISSIONER SEAT 1 (Vote for One)**

Mark Mustian

Write-in JOE MILLER

**CONGRESSIONAL**

**REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)**

Mark Mulligan

Allen Boyd

Write-in

**DISTRICT COURT OF APPEAL**

Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office?

YES

NO

**DISTRICT COURT OF APPEAL**

Shall Judge Margaret H. Davis of the First District Court of Appeal be retained in office?

YES

NO

**DISTRICT COURT OF APPEAL**

Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office?

YES

NO

**DISTRICT COURT OF APPEAL**

Shall Judge Rocky L. Pabson of the First District Court of Appeal be retained in office?

YES

NO

**DISTRICT COURT OF APPEAL**

Shall Judge Clay Roberts of the First District Court of Appeal be retained in office?

YES

NO

**NONPARTISAN COUNTY**

**COUNTY COMMISSIONER AT LARGE, GROUP 1 (Vote for One)**

Nina Ashwell Richardson

Sean Desmond

**MUNICIPAL**

**CITY COMMISSIONER SEAT 1 (Vote for One)**

Mark Mustian

Write-in JOE MILLER

**NONPARTISAN SPECIAL DISTRICT**

**OCHLOCKNEE RIVER SOIL & WATER CONSERVATION DISTRICT 1 SUPERVISOR (Vote for One)**

Brian Acosta

Sean McCaym

**VOTE BOTH SIDES OF BALLOT**

FRONT Card 2 Ballot 2509 \*2509\*

- Voter writes in a candidates name, but doesn't fill in the corresponding voting target – **vote is lost**
- Questions:
  - How often does this occur?
  - What trends are there when this happens?
  - How do you detect this accurately, quickly, and with minimal human effort?

# Our Goals

1. Given a large dataset of scanned ballots, develop a system to accurately and efficiently detect write-in marks without using the corresponding voting target
2. Apply this to a real election and examine the results to see how voters actually use write-in slots on ballots and infer trends or possible sources of error



# Experimental Setup



# Dataset

**OFFICIAL GENERAL ELECTION BALLOT**  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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<b>PRESIDENT AND VICE PRESIDENT</b>		<b>LEGISLATIVE</b>		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office?	
<b>PRESIDENT AND VICE PRESIDENT</b> (Vote for One)		<b>STATE SENATOR</b> <b>DISTRICT 3</b> (Vote for One)		<input type="radio"/> YES <input type="radio"/> NO	
<input type="radio"/> John McCain Sarah Palin REP		<input type="radio"/> Charles S. Dean REP		<b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Norwick, Jr. of the First District Court of Appeal be retained in office?	
<input type="radio"/> Barack Obama Joe Biden DEM		<input type="radio"/> Suzan L. R. Franks DEM		<input type="radio"/> YES <input type="radio"/> NO	
<input type="radio"/> Gloria La Riva Eugene Puryear PSL		<b>STATE REPRESENTATIVE</b> <b>8TH HOUSE DISTRICT</b> (Vote for One)		<b>CIRCUIT JUDGE, 2ND CIRCUIT</b> <b>GROUP 7</b> (Vote for One)	
<input type="radio"/> Chuck Baldwin Darnell Castle CPF		<input type="radio"/> Alan Williams DEM		<input type="radio"/> Lisa Raleigh	
<input type="radio"/> Gene Ammondson Leroy Pfaffen PRO		<input type="radio"/> Robert Maddox NPA		<input type="radio"/> Frank E. Sheffield	
<input type="radio"/> Bob Barr Wayne A. Root LBT		<input type="radio"/> Write-in		<input type="radio"/> Nina Ashenafi Richardson	
<input type="radio"/> Thomas Robert Stevens Aiden Link OBJ		<b>NONPARTISAN JUDICIAL</b>		<input type="radio"/> Sean Desmond	
<input type="radio"/> James Harris Alyson Kennedy SWP		<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office?		<b>COUNTY JUDGE</b> <b>GROUP 5</b> (Vote for One)	
<input type="radio"/> Cynthia McKinney Rosa Clemente GRE		<input type="radio"/> YES		<input type="radio"/> Nina Ashenafi Richardson	
<input type="radio"/> Alan Keyes Brian Rothbough AIP		<input type="radio"/> NO		<input type="radio"/> Sean Desmond	
<input type="radio"/> Ralph Nader Mait Gonzalez ECO		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office?		<b>NONPARTISAN COUNTY</b>	
<input type="radio"/> Brian Moore Stewart Alexander SPF		<input type="radio"/> YES		<b>COUNTY COMMISSIONER</b> <b>AT LARGE, GROUP 1</b> (Vote for One)	
<input type="radio"/> Charles Jay John Wayne Smith BTP		<input type="radio"/> NO		<input type="radio"/> Akin Akinyemi	
<input type="radio"/> Write-in		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Marguerite H. Davis of the First District Court of Appeal be retained in office?		<input type="radio"/> Ed DePuy	
<b>CONGRESSIONAL</b>		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office?		<b>MUNICIPAL</b>	
<b>REPRESENTATIVE IN CONGRESS</b> <b>2ND CONGRESSIONAL DISTRICT</b> (Vote for One)		<input type="radio"/> YES		<b>CITY COMMISSIONER</b> <b>SEAT 1</b> (Vote for One)	
<input type="radio"/> Mark Mulligan REP		<input type="radio"/> NO		<input type="radio"/> Mark Mustian	
<input type="radio"/> Allen Boyd DEM		<b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Poston of the First District Court of Appeal be retained in office?		<input type="radio"/> Write-in	
<input type="radio"/> Write-in		<input type="radio"/> YES		<b>NONPARTISAN SPECIAL DISTRICT</b>	
		<input type="radio"/> NO		<b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION</b> <b>DISTRICT 1 SUPERVISOR</b> (Vote for One)	
				<input type="radio"/> Brian Acosta	
				<input type="radio"/> Sean McGlynn	

**VOTE BOTH SIDES OF BALLOT**

FRONT Cm4 | REP# 1201 "1201"

- We were kindly given **248,334** scanned, double-sided ballot images from the **2008 Leon County General Election** (thanks to Larry Moore, Ion Sancho, and Clear Ballot Group)
- These were in the Premier (Diebold) optical scan format

# Assumptions

**OFFICIAL GENERAL ELECTION BALLOT**  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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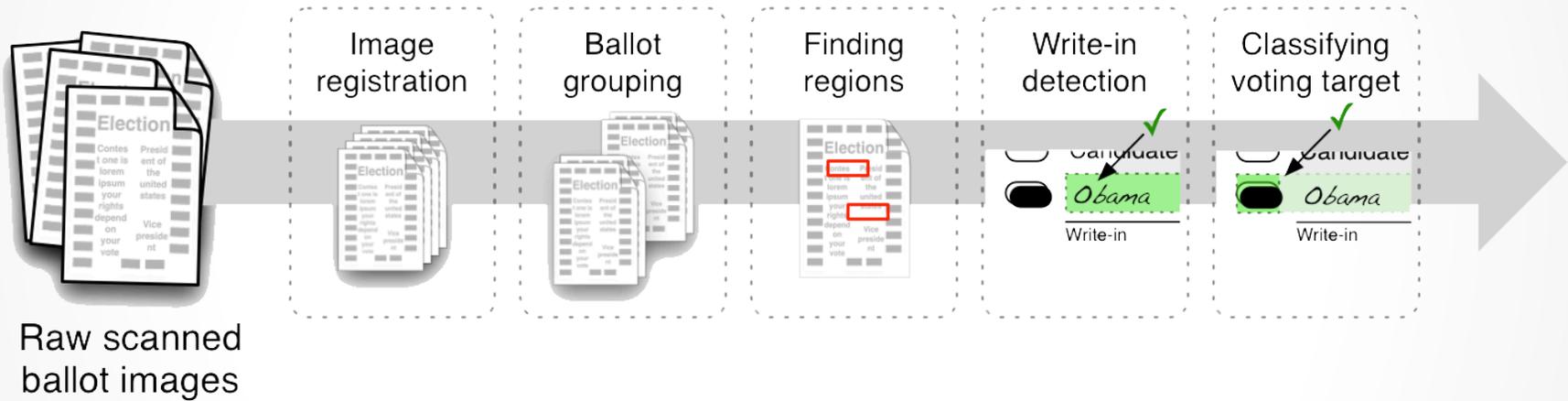
PRESIDENT AND VICE PRESIDENT	LEGISLATIVE	DISTRICT COURT OF APPEAL
<b>PRESIDENT AND VICE PRESIDENT</b> (Vote for One) <input type="radio"/> McCain Sarah Palin REP <input type="radio"/> Barack Obama Joe Biden DEM <input type="radio"/> Gloria La Riva Eugene Puryear PSL <input type="radio"/> Chuck Baldwin Darnell Castle CPF <input type="radio"/> Gene Ammondson Leroy Pletten PRO <input type="radio"/> Bob Barr Wayne A. Root LBT <input type="radio"/> Thomas Robert Stevens Adam Lutz OBU <input type="radio"/> James Harris Alyson Kennedy SWP <input type="radio"/> Cynthia McKinney Rosa Clemente GRE <input type="radio"/> Alan Keyes Brian Rothbough AIP <input type="radio"/> Ralph Nader Matt Gonzalez ECO <input type="radio"/> Brian Moore Stewart Alexander SPF <input type="radio"/> Charles Jay John Wayne Smith BTP <input type="radio"/> Write-in _____	<b>STATE SENATOR</b> DISTRICT 3 (Vote for One) <input type="radio"/> Charles S. Dean REP <input type="radio"/> Susan L. R. Franks DEM <b>STATE REPRESENTATIVE</b> 8TH HOUSE DISTRICT (Vote for One) <input type="radio"/> Alan Williams DEM <input type="radio"/> Robert Maddox NPA <input type="radio"/> Write-in _____ <b>NONPARTISAN JUDICIAL</b> <b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Marguerite H. Davis of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Paston of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Day Roberts of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Norwick, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input type="radio"/> NO <b>CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7</b> (Vote for One) <input type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield <b>COUNTY JUDGE GROUP 5</b> (Vote for One) <input type="radio"/> Nina Ashenafi Richardson <input type="radio"/> Sean Desmond <b>NONPARTISAN COUNTY</b> <b>COUNTY COMMISSIONER AT LARGE, GROUP 1</b> (Vote for One) <input type="radio"/> Alvin Akinyemi <input type="radio"/> Ed DePuy <b>MUNICIPAL</b> <b>CITY COMMISSIONER SEAT 1</b> (Vote for One) <input type="radio"/> Mark Mustian <input type="radio"/> Write-in _____ <b>NONPARTISAN SPECIAL DISTRICT</b> <b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR</b> (Vote for One) <input type="radio"/> Brian Acosta <input type="radio"/> Sean McQryn

**VOTE BOTH SIDES OF BALLOT**

FRONT Cvd4 1 R4FN 1200 "1200"

- We assume we are given blank templates
- We assume ballots have a regular and consistent structure
- (We don't assume to know write-in locations)
- (We don't assume scanned image will be perfect)

# Process



# Image Registration

**2361G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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PRESIDENT AND VICE PRESIDENT	NONPARTISAN JUDICIAL	COUNTY JUDGE GROUP 5 (Vote for One)
<b>PRESIDENT AND VICE PRESIDENT (Vote for One)</b> <input checked="" type="radio"/> John McCain Sarah Palin REP <input type="radio"/> Barack Obama Joe Biden DEM <input type="radio"/> Gloria La Riva Eugene Puryear PSL <input type="radio"/> Chuck Baldwin Darrell Castle CPF <input type="radio"/> Gene Amundson Leroy Plotten PRO <input type="radio"/> Bob Barr Wayne A. Root LBT <input type="radio"/> Thomas Robert Stevens Alden Link OBJ <input type="radio"/> James Harris Alyson Kennedy SWP <input type="radio"/> Cynthia McInerney Rosa Clemente GRE <input type="radio"/> Alan Keyes Brian Robebough AIP <input type="radio"/> Ralph Nader Matt Gonzalez ECO <input type="radio"/> Brian Moore Stewart Alexander SPF <input type="radio"/> Charles Jay John Wayne Smith BTP <input type="radio"/> Write-in	<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Denton of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Marguerite H. Davis of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Ricky L. Tolson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Norwick, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7 (Vote for One)</b> <input checked="" type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield	<input type="radio"/> Nina Ashenafi Richardson <input checked="" type="radio"/> Sean Desmond <b>NONPARTISAN COUNTY COMMISSIONER AT LARGE, GROUP 1 (Vote for One)</b> <input checked="" type="radio"/> Akin Akinyemi <input type="radio"/> Ed DePuy <b>NONPARTISAN SPECIAL DISTRICT OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR (Vote for One)</b> <input type="radio"/> Brian Acosta <input checked="" type="radio"/> Sean McGlynn

**CONGRESSIONAL REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)**  
 Mark Mulligan REP  
 Allen Boyd DEM  
 Write-in

**VOTE BOTH SIDES OF BALLOT**

FRONT Card 4 Rep/Fec 2361 \*\*2361\*\*

- Align each ballot to a universal coordinate system
- Necessary for accuracy of further steps
- Robust against folds, skews, and tears in images



Raw scanned ballot images

# Image Registration

**2361G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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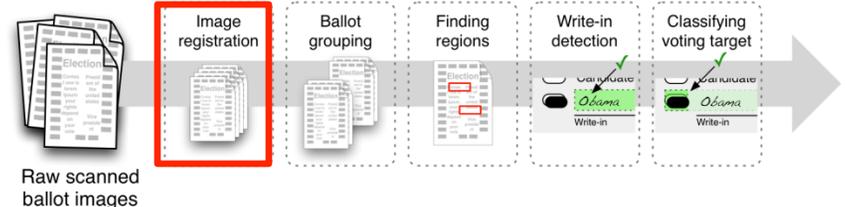
PRESIDENT AND VICE PRESIDENT	NONPARTISAN JUDICIAL	COUNTY JUDGE GROUP 5 (Vote for One)
<b>PRESIDENT AND VICE PRESIDENT (Vote for One)</b> <input checked="" type="radio"/> John McCain Sarah Palin REP <input type="radio"/> Barack Obama Joe Biden DEM <input type="radio"/> Gloria La Riva Eugene Paryear PSL <input type="radio"/> Chuck Baldwin Darrell Castle CPF <input type="radio"/> Gene Ammondson Leroy Pletten PRO <input type="radio"/> Bob Barr Wayne A. Root LBT <input type="radio"/> Thomas Robert Stevens Alken Link OBJ <input type="radio"/> James Harris Alyson Kennedy SWP <input type="radio"/> Cynthia McKinney Rosa Clemente GRE <input type="radio"/> Alan Keyes Brian Robinson AIP <input type="radio"/> Ralph Nader Matt Gonzalez ECO <input type="radio"/> Brian Moore Stewart Alexander SPI <input type="radio"/> Charles Jay John Wayne Smith BTP <input type="radio"/> Write-in	<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Marguerite H. Davis of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Ricky L. Hobson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Nortwick, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7 (Vote for One)</b> <input checked="" type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield	<input type="radio"/> Nina Asherall Richardson <input checked="" type="radio"/> Sean Desmond <b>NONPARTISAN COUNTY</b> <b>COUNTY COMMISSIONER AT LARGE, GROUP 1 (Vote for One)</b> <input checked="" type="radio"/> Alvin Akinyemi <input type="radio"/> Ed DePuy <b>NONPARTISAN SPECIAL DISTRICT</b> <b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR (Vote for One)</b> <input type="radio"/> Brian Acosta <input checked="" type="radio"/> Sean McDynn
<b>CONGRESSIONAL</b> <b>REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)</b> <input type="radio"/> Mark Mulligan REP <input checked="" type="radio"/> Allen Boyd DEM <input type="radio"/> Write-in		

VOTE BOTH SIDES OF BALLOT

FRONT Card 4 Rep/Put 2361 "2361"

- Identify every hashmark along the side using *template matching*

- OK if some are missing or go undetected



# Image Registration

**2361G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

• TO VOTE, COMPLETELY FILL IN THE OVAL  NEXT TO YOUR CHOICE.  
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PRESIDENT AND VICE PRESIDENT	NONPARTISAN JUDICIAL	COUNTY JUDGE GROUP 5 (Vote for One)
<b>PRESIDENT AND VICE PRESIDENT (Vote for One)</b> <input checked="" type="radio"/> John McCain Sarah Palin REP <input type="radio"/> Barack Obama Joe Biden DEM <input type="radio"/> Gloria La Riva Eugene Puryear PSJ <input type="radio"/> Chuck Baldwin Darrell Castle CPF <input type="radio"/> Gene Amundson Leroy Pletten PRO <input type="radio"/> Bob Barr Wayne A. Root LBT <input type="radio"/> Thomas Robert Stevens Alden Link OBJ <input type="radio"/> James Harris Alyson Kennedy SWP <input type="radio"/> Cynthia McKinney Rosa Clemente GRE <input type="radio"/> Alan Keyes Brian Robinson AIP <input type="radio"/> Ralph Nader Mark Gonzalez ECO <input type="radio"/> Brian Moore Stewart Alexander SPI <input type="radio"/> Charles Jay John Wayne Smith BTP <input type="radio"/> Write-in	<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Denton of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Margeorie H. Davis of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Ricky L. Pridson of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Nortwick, Jr. of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<input type="radio"/> Nina Ashenafi Richardson <input checked="" type="radio"/> Sean Desmond <b>NONPARTISAN COUNTY</b> <b>COUNTY COMMISSIONER AT LARGE, GROUP 1 (Vote for One)</b> <input checked="" type="radio"/> Alan Akanyemi <input type="radio"/> Ed DePuy <b>NONPARTISAN SPECIAL DISTRICT</b> <b>OCHLOCKONEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR (Vote for One)</b> <input type="radio"/> Brian Acosta <input checked="" type="radio"/> Sean McGlynn
<b>CONGRESSIONAL</b> <b>REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)</b> <input type="radio"/> Mark Mulligan REP <input checked="" type="radio"/> Allen Boyd DEM <input type="radio"/> Write-in	<b>CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7 (Vote for One)</b> <input checked="" type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield	

VOTE BOTH SIDES OF BALLOT

FRONT Card 4 Rev/Nov 2361 "2361"

- Linear regression along each edge using the hashmarks as points

- (Notice the slight leftwards skew in the image as shown by the lines)



Raw scanned ballot images



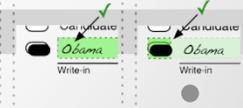
Image registration

Ballot grouping

Finding regions

Write-in detection

Classifying voting target



# Image Registration

**2361G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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PRESIDENT AND VICE PRESIDENT	NONPARTISAN JUDICIAL	COUNTY JUDGE GROUP 5 (Vote for One)
<b>PRESIDENT AND VICE PRESIDENT (Vote for One)</b> <input checked="" type="radio"/> John McCain <input type="radio"/> Sarah Palin REP.	<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO	<input type="radio"/> Nina Ashenall Richardson <input checked="" type="radio"/> Sean Desmond

Allen Boyd DEM

Write-in

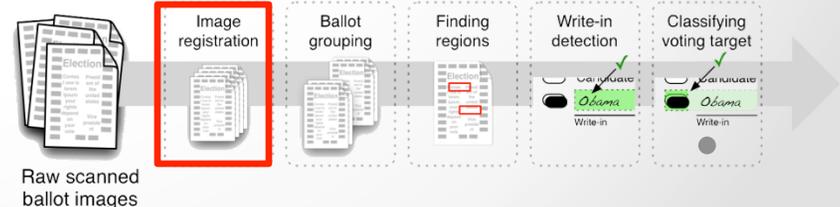
CONGRESSIONAL	DISTRICT COURT OF APPEAL	DISTRICT COURT OF APPEAL	DISTRICT COURT OF APPEAL	CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7 (Vote for One)
<b>REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT (Vote for One)</b> <input checked="" type="radio"/> Allen Boyd DEM <input type="radio"/> Write-in	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph L. Lewis, Jr. of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Ricky L. Pridgen of the First District Court of Appeal be retained in office? <input type="radio"/> YES <input checked="" type="radio"/> NO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office? <input checked="" type="radio"/> YES <input type="radio"/> NO	<input checked="" type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield

**VOTE BOTH SIDES OF BALLOT**

FRONT Card 4 RefNo: 2361 \*2361\*

- Correspond every hashmark with the hashmark on the canonical ballot (template)

- Perform an affine transformation



# Ballot Grouping

**2361G** OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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<b>PRESIDENT AND VICE PRESIDENT</b>		<b>NONPARTISAN JUDICIAL</b>	<b>COUNTY JUDGE GROUP 5</b> (Vote for One)
<b>PRESIDENT AND VICE PRESIDENT</b> (Vote for One)		<b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office?	<input type="radio"/> Nina Ashenafi Richardson <input checked="" type="radio"/> Sean Desmond
<input checked="" type="radio"/> John McCain Sarah Palin REP.	<input type="radio"/> Barack Obama Joe Biden DEM.	<input checked="" type="radio"/> YES <input type="radio"/> NO	<b>NONPARTISAN COUNTY</b>
<input type="radio"/> Gloria La Riva Eugene Puryear PSL.	<input type="radio"/> Chuck Baldwin Darrell Cardle CPF.	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Robert T. Benton of the First District Court of Appeal be retained in office?	<b>COUNTY COMMISSIONER AT LARGE, GROUP 1</b> (Vote for One)
<input type="radio"/> Gene Amundson Leroy Pletten PRO.	<input type="radio"/> Bob Barr Wayne A. Root LBT.	<input checked="" type="radio"/> YES <input type="radio"/> NO	<input checked="" type="radio"/> Akin Akinyemi <input type="radio"/> Ed DePuy
<input type="radio"/> Thomas Robert Stevens Aldem Link OBJ.	<input type="radio"/> James Harris Alyson Kennedy SWP.	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Margeurite H. Davis of the First District Court of Appeal be retained in office?	<b>NONPARTISAN SPECIAL DISTRICT</b>
<input type="radio"/> Cynthia McKinney Rosa Clemente GRE.	<input type="radio"/> Alan Keyes Brian Rothbough AIP.	<input type="radio"/> YES <input checked="" type="radio"/> NO	<b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION DISTRICT 1 SUPERVISOR</b> (Vote for One)
<input type="radio"/> Ralph Nader Matt Gonzalez ECO.	<input type="radio"/> Brian Moore Stewart Alexander SPF.	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office?	<input type="radio"/> Brian Acosta <input checked="" type="radio"/> Sean McGlynn
<input type="radio"/> Brian Moore Stewart Alexander SPF.	<input type="radio"/> Charles Jay John Wayne Smith BTP.	<input checked="" type="radio"/> YES <input type="radio"/> NO	
Write-in		<b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Norwick, Jr. of the First District Court of Appeal be retained in office?	
<b>CONGRESSIONAL</b>		<input type="radio"/> YES <input checked="" type="radio"/> NO	
<b>REPRESENTATIVE IN CONGRESS 2ND CONGRESSIONAL DISTRICT</b> (Vote for One)		<b>CIRCUIT JUDGE, 2ND CIRCUIT GROUP 7</b> (Vote for One)	
<input checked="" type="radio"/> Mark Mulligan Alton Boyd REP.	<input type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield DEM.	<input checked="" type="radio"/> Lisa Raleigh <input type="radio"/> Frank E. Sheffield	
Write-in			

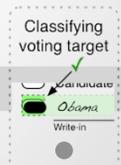
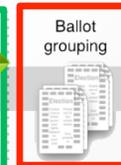
**VOTE BOTH SIDES OF BALLOT**

FRONT Card 4 RefPt 2361 \*2361\*

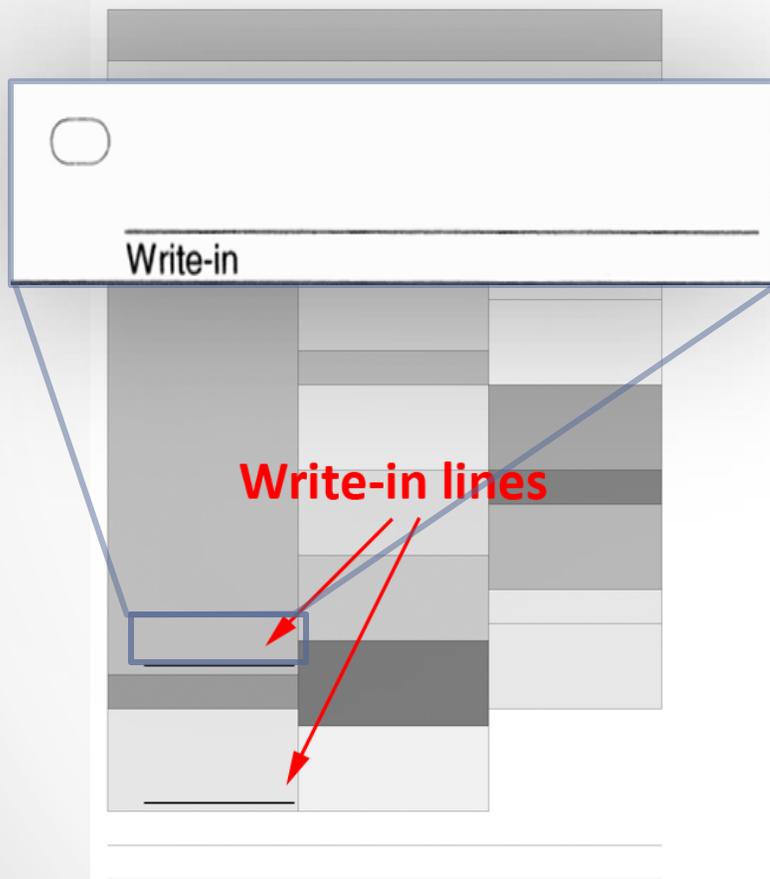
- We group all the ballots of the same style together
- We use the precinct number for this
- Match each style with one of the templates



Raw scanned ballot images



# Finding Write-in Lines



- First we look for the write-in lines
- Notice that they are horizontal lines contained entirely within a contest box
- Use form extraction



# Finding Write-in Regions

OFFICIAL GENERAL ELECTION BALLOT  
LEON COUNTY, FLORIDA  
NOVEMBER 4, 2008

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<b>PRESIDENT AND VICE PRESIDENT</b> <b>PRESIDENT AND VICE PRESIDENT</b> (Vote for One) <input type="checkbox"/> John McCain Sarah Palin REP <input type="checkbox"/> Barack Obama Joe Biden DEM <input type="checkbox"/> Gloria La Riva Eugene Puryear PSL <input type="checkbox"/> Chuck Baldwin Darnell Castle CPF <input type="checkbox"/> Gene Aronson Lacey Pflizen PRO <input type="checkbox"/> Bob Barr Wayne A. Root LBT <input type="checkbox"/> Thomas Robert Stevens Alden James OBJ	<b>LEGISLATIVE</b> <b>STATE SENATOR</b> <b>DISTRICT 3</b> (Vote for One) <input type="checkbox"/> Charles S. Dean REP <input type="checkbox"/> Suzan L. R. Franks DEM <b>STATE REPRESENTATIVE</b> <b>9TH HOUSE DISTRICT</b> (Vote for One) <input type="checkbox"/> Peter Souleire REP <input type="checkbox"/> Michelle Rehminksi Vesilinda DEM <input type="checkbox"/> John Shaw NPA <b>NONPARTISAN JUDICIAL</b> <b>JUSTICE OF THE SUPREME COURT</b> Shall Justice Charles T. Wells of the Supreme Court be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Clay Roberts of the First District Court of Appeal be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge William A. Van Nortwick, Jr. of the First District Court of Appeal be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO <b>CIRCUIT JUDGE, 2ND CIRCUIT</b> <b>GROUP 7</b> (Vote for One) <input type="checkbox"/> Lisa Raleigh <input type="checkbox"/> Frank E. Sheffield <b>COUNTY JUDGE</b> <b>GROUP 5</b> (Vote for One) <input type="checkbox"/> Akin Akinyemi <input type="checkbox"/> Ed DePuy
<b>CONGRESSIONAL</b> <b>REPRESENTATIVE IN CONGRESS</b> <b>2ND CONGRESSIONAL DISTRICT</b> (Vote for One) <input type="checkbox"/> Mark Mulligan REP <input type="checkbox"/> Allen Boyd DEM <input type="checkbox"/> Write-in	<b>DISTRICT COURT OF APPEAL</b> Shall Judge Marguerite H. Davis of the First District Court of Appeal be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Joseph Lewis, Jr. of the First District Court of Appeal be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO <b>DISTRICT COURT OF APPEAL</b> Shall Judge Rocky L. Patton of the First District Court of Appeal be retained in office? <input type="checkbox"/> YES <input type="checkbox"/> NO	<b>NONPARTISAN SPECIAL DISTRICT</b> <b>OCHLOCKNEE RIVER SOIL &amp; WATER CONSERVATION</b> <b>DISTRICT 1 SUPERVISOR</b> (Vote for One) <input type="checkbox"/> Brian Acosta <input type="checkbox"/> Sean McGynn

Write-in

VOTE BOTH SIDES OF BALLOT

FRONT Card 8 RepPt 4153 "4153" FOR PROOF ONLY 06/01/09 14:43:24

- Given the write-in lines, we scan upward until whitespace ends
- This gives us a rectangular box that becomes our write-in region



Raw scanned ballot images



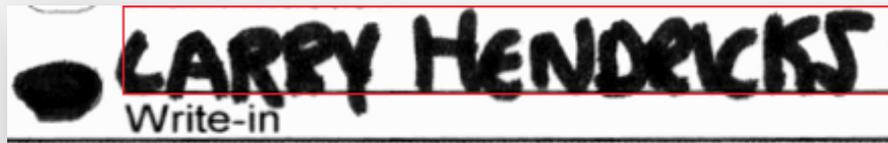
# Write-in Detection



Black Pixels: 8 ❌



Black Pixels: 908 ✅

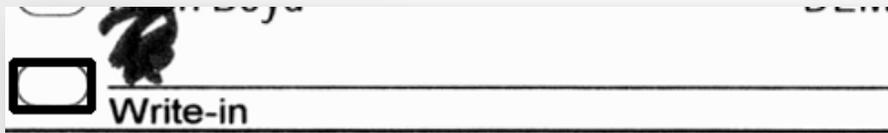


Black Pixels: 7203 ✅

- Count the number of black pixels in the write-in region
- Threshold it at a conservative (low) number, and consider anything exceeding the threshold as a mark



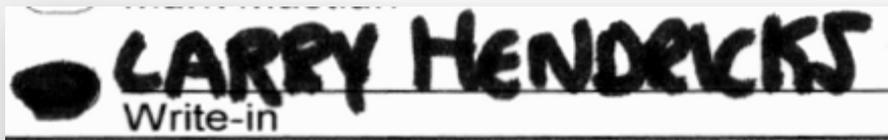
# Classifying Voting Targets



Matched (Unfilled) ❌



Matched (Unfilled) ❌



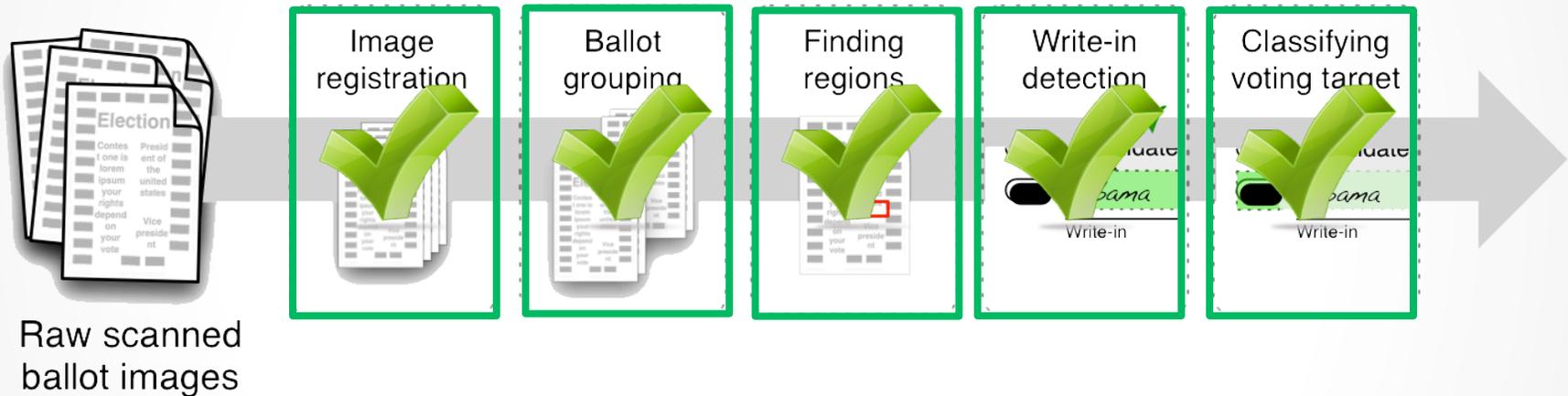
Not Matched (Filled) ✅

- Lastly, we classify the voting target for each write-in as filled or unfilled
- Do this through template matching the voting target



Raw scanned ballot images

# Process Finished...



...Results!

# Analysis on the 2008 Leon County General Election

...



# Amazon's Mechanical Turk

<p><b>CITY COMMISSIONER SEAT 1 (Vote for One)</b></p> <p><input type="radio"/> Mark Mustian</p> <p><input type="radio"/> <u>JOE MILLER</u> Write-in</p> <p><input type="button" value="Submit"/></p>	<p>Is there handwriting present in the "Write-in" section?</p> <p>Yes <input checked="" type="radio"/> No <input type="radio"/></p> <p>Is it clearly a person's name? (if it is a scribble or a crossed out name, please answer "No")</p> <p>Yes <input checked="" type="radio"/> No <input type="radio"/></p> <p>The handwritten name (if you answered "Yes" to the question above):</p> <p>Joe Miller</p>
<h2>Example Solution</h2>	

An example task for the participant to do

# Common Types of Marks

Actual votes **lost**

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

JOE MILLER  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

Larry Hendricks  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

Sam Bowker  
Write-in

**STATE REPRESENTATIVE  
8TH HOUSE DISTRICT  
(Vote for One)**

Alan Williams DEM

Robert Maddox NPA

Hubert Brown  
Write-in

# Common Types of Marks

## Emphasis votes Εμφρασις

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

Mulligan  
Write-in

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

Allen Boyd  
Write-in

**STATE REPRESENTATIVE  
8TH HOUSE DISTRICT  
(Vote for One)**

Alan Williams DEM

Robert Maddox NPA

Robert Maddox  
Write-in

**STATE REPRESENTATIVE  
8TH HOUSE DISTRICT  
(Vote for One)**

Alan Williams DEM

Robert Maddox NPA

Alan Williams  
Write-in

# Common Types of Marks

## Conflict votes

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian *Larry Hendricks*

~~Alvin Akinjemi~~  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

*Moise Duge*  
Write-in

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

*Robert Ortiz*  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

*Gregory W. Whitaker*  
Write-in

# Common Types of Marks

Non-serious votes 😊

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

BINGO THE DOG  
Write-in

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

MICKEY MOUSE  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

Ronald McDonald  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

Jesus Christ  
Write-in

# Common Types of Marks

## Quantifying Votes...?

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

\_\_\_\_\_  
Write-in

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

*NEITHER* \_\_\_\_\_  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

*None* \_\_\_\_\_  
Write-in

**CITY COMMISSIONER  
SEAT 1  
(Vote for One)**

Mark Mustian

*unknown* \_\_\_\_\_  
Write-in



$$\frac{784}{1618} = 48\%$$

# Statistics

Write-in Regions

Voting Target

	Marked	Unmarked	Total
Filled	<b>834</b> <b>(0.226%)</b>	78 (0.021%)	911 (0.247%)
Unfilled	<b>784</b> <b>(0.213%)</b>	366981 (99.54%)	367766 (99.75%)
Total	<b>1618</b> <b>(0.439%)</b>	367059 (99.56%)	368677

# Detailed Results

- 1618 write-in votes (**834** bubbled, **784** not)
- **453** *emphasis* votes (**3** bubbled, **450** not)
- **17** *conflict* votes (**0** bubbled, **17** not)
- **54** *non-serious* votes (**41** bubbled, **13** not)
- **54** *quantifying* votes (**27** bubbled, **27** not)
- **16** *stray marks* (**0** bubbled, **16** not)
  
- Total Lost votes: **261 (16% of write-in votes)**

# Conclusion

- We developed techniques to accurately detect write-in marks from optical scan ballots. We did this with only partial knowledge about the ballot, and minimal human assistance.
- We demonstrated its feasibility on a large, real-life data set from Leon County, and found surprising results – that in fact, up to 16% of write-in votes that could have been counted in the election were lost.



# The End

**REPRESENTATIVE IN CONGRESS  
2ND CONGRESSIONAL DISTRICT  
(Vote for One)**

Mark Mulligan REP

Allen Boyd DEM

\_\_\_\_\_  
Write-in **Thank You!**

*Disclaimer: This was not a real vote*