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INTRODUCTION

In recent years, the convergence of laws, policies, and information and communication technologies (ICT) has witnessed substantial growth. Within the academic sector, numerous topics are undergoing active research. One such area of exploration involves the potential enhancements algorithms can offer to laws and policies writing. Given that my academic background spans between law, economics and computer science, I have chosen this particular theme for my thesis. In this thesis I algorithmically represent and implement a segment of the U.S. presidential electoral process, and provide a brief compendium of the main electronic voting machines.

I would like to extend my sincere gratitude to Professor Silvia Crafa, my dedicated supervisor, for her invaluable guidance.

Best regards, Pietro Fracalanza

1 – OVERVIEW OF THE U.S.A. PRESIDENTIAL ELECTIONS

As briefly indicated in the introduction of the thesis, the underlying theme revolves around the question: "How can algorithms enhance legal writing?" While there is no definitive answer to this question due to the ongoing nature of research in this field, my thesis aims to provide insight into how an algorithm could be applied to legal contexts. Laws that describe procedures, as they outlie a series of steps, are particularly suitable for algorithmic representation. For this reason, my thesis focuses on representing a certain portion of the USA Presidential electoral process. However, before delving into the core of the thesis – the algorithm and its implementation – it is foundamental to grasp the workings of the entire USA Presidential electoral process.

Voting systems in Western democracies can be broadly categorized into two groups: direct and indirect systems. In direct systems[1], citizens cast their votes directly for the individual or position they are supporting, such as the Prime Minister. On the other hand, in indirect systems[2], citizens vote to elect representatives, who subsequently cast direct votes on their behalf for the positions or decisions in question. As an example the voting system for the Prime Minister in Italy[3] is indirect. Italy follows a parliamentary system where voters cast their ballots for political parties or coalitions rather than directly for an individual candidate for Prime Minister, whereas in France the citizens directly elect the President[4].

The United States employs an indirect presidential electoral system[5]. In this system, citizens' votes are utilized to determine the number of representatives, known as Electors, allocated to a particular political party. These Electors then collectively constitute the Electoral College, casting their votes to elect the President, typically the nominee of their own party.

Indeed, the citizens' voting session is commonly referred to as the "popular vote," conducted at the local level within each State. In contrast, the Electoral College voting session, known as the "electoral vote," takes place at the federal level. The allocation of Electors varies from State to State, proportionate to the State's population.

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[1] Theo Schiller, *Direct Democracy*, Encyclopaedia Britannica, https://www.britannica.com/topic/direct-democracy

[2] Sanat Pai Raikar, *Representative Democracy*, Encyclopaedia Britannica, https://www.britannica.com/topic/representative-democracy

[3]Christopher John Wickham,Paola E. Signoretta ans Others, *Political process*, Encyclopaedia Britannica, https://www.britannica.com/place/Italy/Political-process

[4]Ministère de l'Europe et des Affaires étrangères, *How is the President of the French Republic elected?*, https://www.diplomatie.gouv.fr/IMG/pdf/infographie_election_pr_vaccess_en_cle814c2a.pdf

[5] USA.gov (official website of the USA government), https://www.usa.gov/presidential-election-process

The next subchapter provides an in-depth, step-by-step elucidation of the complete electoral process. Following this, the thesis delves into its focal point: the algorithm and its implementation. Finally, a dedicated chapter serves as a concise compendium on the primary electronic voting machines.

1.1 – The electoral process step by step

PRIMARIES AND CAUCASES (1-2 years before the election):

[6]The process begins with primary elections and caucuses held in each State. These are the political parties internal indirect elections, allowing voters from each political party to cast their vote for a nominee for presidency candidate. The outcomes of these primary and caucus contests dictate the allocation of Delegates (the voters representatives) to each candidate, who will later advocate and vote for them at the respective party National Conventions. The only parties truly relevant are the Democratic and Republican ones, so much that even though there are also other parties, they're so small that the USA political system is considered de facto bipartisan.

NATIONAL CONVENTIONS (Summer of election year):

[7]Each political party holds a National Convention to officially nominate their candidate for the presidency. During these events, the Delegates previously voted by the party members cast their votes for the presidential candidate of the party. The conventions also serve as a platform for the parties to unveil their official party platforms and rally support for their chosen candidate.

[6] USA.gov (official website of the USA government), https://www.usa.gov/primaries-caucuses
[7] USA.gov (official website of the USA government), https://www.usa.gov/national-conventions

CAMPAIGNING (Summer and Fall of election year):

After securing their party's nomination, the presidential candidates campaign across the country, seeking to win the support of voters in the general election.

This phase includes debates between the candidates, extensive media coverage, and a focus on key swing States where the election outcome is often uncertain. The swing States are the ones where statistically doesn't always win the same party, thus where the election outcome could vary in each presidential elections[8]. As an example Wyoming and Oregon are considered respectively a republican and democratic State, since those parties win there in almost every presidential election, whereas Nevada is a swing State. Therefore the presidential candidates campaign and media coverage is conducted more intensively in a swing State rather than in one where is statistically more likely to win.

ELECTION DAY AND POPULAR VOTE: election of the Electoral College (First Tuesday in November of election year):

Registered voters[9] across the United States cast their vote for a presidential candidate. In the USA, differently from Italy, the citizens don't automatically receive a voting permit, they must enroll themselves in an official voter registration system, that's why they're called "registered voters". It's worth remember that, as previously mentioned, this is the so called "popular vote" , which is used to create the Electoral College. Even though the voters in their ballots put an X on a presidential candidate's name[10], they do not directly elect the President. The outcome of this elections in every State is the allocation of a certain number of Electors to the winning party, which is further explained in the next step. The Election Day has been scheduled on the first Tuesday in November primarily for historical reasons, but it was formally established as such by the enactment of the 1845 Act[11].

[8] Jessica Pearce Rotondi, *What Are Swing States and Why Are They Critical in US Elections?,* History, https://www.history.com/news/swing-states-presidential-elections

[9] USA.gov (official website of the USA government), https://www.usa.gov/voter-registration

[10] Roberto di Cosmo, *On privacy and anonymity in electronic and non electronic voting: the ballot-as-signature attack*, ReasearchGate, https://www.researchgate.net/figure/Example-sample-ballot-from-an-actual-US-election_fig2_255628349

[11] Jhon M. Cunnongham, *Why are elections held on Tuesday?*, Encyclopaedia Britannica, https://www.britannica.com/story/why-are-us-elections-held- on-tuesdays

ELECTION OF THE PRESIDENT[12] (December following the election):

[13]The number of Electors per state is indirectly decided through the "Method of Equal Proportions", which is used after every decennial census to allocate the House of Rapresentatives seats to each State based on their population (U.S. Code Title 13 Chapter 5 Subchapter II, Section 141). It is not mentioned in a specific law but decided by the Census Bureau.

In the Electoral College system, each state is allocated a certain number of Electors based on its representation in Congress[14].

Each State has the autonomy to determine its approach on allocating Electors among political parties. The most common approach employed by the majority of states is the "winner-takes-all" system, in which the party of the presidential candidate who garners the majority of the popular votes in a State is awarded all of that State's Electors number. However, an exception to this practice is observed in just two states: Maine and Nebraska, where a proportional allocation system is in place[15].

The presidential candidate who secures the absolute majority of the electoral votes -which is 270 votes[16] since the total number of Electors is 538- becomes the President-elect.

As stated in the XII Amendment, in case that any presidential candidate is able to secure the absolute majority during the Electoral College elections, the House of Representatives will elect the President after a new election that works this way:

Each State's delegation at the House of Representative (the members of the House of Rapresentatives from each States elected locally during legislative elections) holds a single vote, therefore one vote per State, requiring candidates to obtain a minimum of 26 votes for victory. Within each delegation, an internal vote is conducted to determine their chosen candidate. In case that no presidential candidate secures the absolute majority, this process is repeated until a presidential candidate emerges as the winner.

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[12] USA Constitution, *USA Constitution XII Amendment*, https://www.senate.gov/about/origins-foundations/senate-and-constitution/constitution.htm

[13] United States Census Buraeu, *Computing Apportionment*, https://www.census.gov/topics/public-sector/congressional-apportionment/about/computing.html

[14] USA Constitution, *USA Constitution, Article II, Section 1, Clause 2* https://constitution.congress.gov/browse/article-2/section-1/clause-2/

[15] Patrick Hummel, *Proportional vs winner – take – all electoral vote allocation*, JSTOR, https://www.jstor.org/stable/41483702

[16] USA.gov (official website of the USA government), https://www.usa.gov/electoral-college

INAUGURATION (January 20th of the year following the election)

The presidential inauguration takes place in Washington, D.C., where the President-elect is sworn into office and officially becomes the President of the United States. It has been scheduled on January 20th by the 20th Amendment.[17]

[17] USA Constitution, *USA Constitution XX Amendment*, https://www.senate.gov/about/origins-foundations/senate-and-constitution/constitution.htm

2 - ALGORITHMIC REPRESENTATION OF THE FEDERAL SECTION OF THE ELECTORAL PROCESS

The algorithm presented in this chapter exclusively addresses the federal section of the presidential electoral process. It specifically encapsulates the provisions outlined in the XII Amendment, which governs this federal aspect of the presidential elections. The algorithm takes into account the results of popular elections from each State as input, processing them to determine the victorious President-elect, adhering to the guidelines stipulated in the XII Amendment:

"The Electors shall meet in their respective states and vote by ballot for President and Vice-President, one of whom, at least, shall not be an inhabitant of the same state with themselves; they shall name in their ballots the person voted for as President, and in distinct ballots the person voted for as Vice-President, and they shall make distinct lists of all persons voted for as President, and of all persons voted for as Vice-President, and of the number of votes for each, which lists they shall sign and certify, and transmit sealed to the seat of the government of the United States, directed to the President of the Senate;—The President of the Senate shall, in the presence of the Senate and House of Representatives, open all the certificates and the votes shall then be counted;—The person having the greatest Number of votes for President, shall be the President, if such number be a majority of the whole number of Electors appointed; and if no person have such majority, then from the persons having the highest numbers not exceeding three on the list of those voted for as President, the House of Representatives shall choose immediately, by ballot, the President. But in choosing the President, the votes shall be taken by states, the representation from each state having one vote; a quorum for this purpose shall consist of a member or members from two-thirds of the states, and a majority of all the states shall be necessary to a choice."

Before designing the algorithm is essential to consider the following premises:

- The possibility of a tie occurring between two or more presidential candidates is negligible. This assumption is rooted in the fact that tie-breaking methods vary significantly from State to State. Consequently, we consider such ties to have been resolved prior to the algorithm's execution, as the algorithm exclusively addresses the federal section of the presidential electoral process.

- Three parties partecipate to the elections.

- The algorithm operates on a pre-defined set of informations, which are the names of the parties and of the presidential candidates, the number of Electors and their respective names.

- Every Elector votes for the presidential candidate of his party.

- The part of the XII Amendment regarding the case in which no presidential candidate secures an absolute majority is not considered in the algorithm as it would required different inputs and a separate algorithm.

Thus considered, we can move on to the algorithm:

```
INPUT: popular votes received by every party --> votes_party_n = int

   1     Repeat for every State S (+Washingotn D.C.):

                 Compare the number of votes for every presidential
                 candidate and find the higher, therefore the winner

                 Assign the name of the winning presidential candidate's
                 party P to a variable

   2     Create a list of dictionaries representing the Electoral
         College called electoral_college, where every dictionary
         represent a State, and has the following structure:

                 {S:P, E:int, N:[]}

         S = State name
         P = Popular vote winning party
         E = number of Electors for that State
         N = Names of the Electors

   3     For every dictionary in electoral_college:

                 Check which one is the winning party P

                 Check how many Electors, and therefore votes for that
                 party presidential candidate, it holds

   4     Find the winning presidential candidate C

   5     In case of a tie between one or more presidential candidates,
         or in case of no absolute majority, return respectively the
         presidential candidates involved in the tie or False.

OUTPUT: new President-elect, presidential candidates in a tie, or False
```

3 – IMPLEMENTATION

After laying out the algorithm in the previous chapter, I'm going to implement it using Python. Each subchapter contains a recall to the algorithm and the implementation of one or more steps, reported in the subchapters titles. An important premise to consider is that the operations repeated for every State such as in step 1 of the algorithm are always done in alphabetical order, since it’s more functional for the sake of data accessibility.

3.1 – Step 1

Recall:

```
‘’’ Repeat for every State S (+Washingotn D.C.):

        Compare the number of votes for every presidential candidate and
        find the higher, therefore the winner

        Assign the name of the winning presidential candidate's party P to
        a variable ’’’
```

Implementation:

```
# Function to determine which presidential candidate received more votes in the
Election Day, it takes as input the popular votes and returns the winning presidential
candidate’s party as output. As we stated the parties’ names are pre-defined.

def popular_results (votes_partyone, votes_partytwo, votes_partythree):

    winner_party = max (votes_partyone, votes_partytwo, votes_partythree)

    if winner_party ==  votes_partyone:
        return ‘name_partyone’

    if winner_party ==  votes_partytwo:
```

```
                    return ‘name_partytwo’


            if winner_party ==  votes_partythree:
                    return ‘name_partythree’
```

```
# Determine the winner presidential candidate’s party P in every State S by repeating the following snippet, and add the result to the winners list. let’s use Alabama as an example

winners = []

alabama_winner = popular_results (votes_partyone, votes_partytwo, votes_partythree)

winners.append(alabama_winner)

                                    ...
```

3.2 – Step 2

Recall:

```
‘’’ Create a list of dictionaries representing the Electoral College called electoral_college, where every dictionary represent a State, and has the following structure:

                {S:P, E:int, N:[# names of the Electors]}

        S = State name
        P = Popular vote winning party
        E = number of Electors for that State
        N = Names of the Electors ‘’’
```

Implementation:

```
# Create the electoral_college lists of dictionary, which as previously mentioned already holds the number and names of the electors. Iter with a for loop through the dictionaries and winners list in order to pair the S keys with a value. Since both lists are alphabetically sorted, using the zip module it’s possible to iterate through both lists and the value in winners list matches the State dictionary in electoral_college.
```

```
electoral_college = [
{‘Alabama’: None, ‘electors’: 9, ‘names’: [str,...,str]}
                    …
]
for dictionary, winner in zip (electoral_college, winners):
             state_key = next (iter (dictionary.keys())) # select the first key
             dictionary (state_key) = winner
```

3.3 – Step 3 – 4 - 5

Recall:

```
          ‘’’ For every dictionary in electoral_college:
                    Check which one is the winning party P
                    Check how many Electors, and therefore votes for that party
                    presidential candidate, it holds

              Find the winning presidential candidate C
             In case of a tie between one or more presidential candidates, or in case
             of no  absolute majority, return respectively the presidential candidates
             involved in the tie or False.‘’’
```

Implementation:

```
# Initialize a counter for every presidential candidate
candidateone_counter = 0
candidatetwo_counter = 0
candidatethreee_counter = 0
```

```
# Count the votes for every presidential candidate. As we stated, we assume that every Elector votes for his own party presidential candidate and the parties_names are pre-defined.

for dictionary in electoral_college:

            state_key = next (iter (dictionary.keys())) # select the first key

            if mydictionary (state_key) == ‘name_partyone’:
                  votes = mydictionary (electors)
                  candidateone_counter+=votes

            if mydictionary (state_key) == ‘name_partytwo’:
                  votes = mydictionary (electors)
                  candidatetwo_counter+=votes

            if mydictionary (state_key) == ‘name_partythree’:
                  votes = mydictionary (electors)
                  candidatethree_counter+=votes

# Determine which presidential candidate received more votes and if there’s an absolute majority. If so, declare the new President-elect, otherwise return False or the names of the candidates involved in the tie. As we previously reported, the names of the presidential candidates are pre-defined.

electoral_votes = {‘name_candidateone’ = candidateone_counter,
                  ‘name_candidatetwo’ = candidatetwo_counter,
                  ‘name_candidatethree’ = candidatethree_counter }

tie = len(set(dizionario_numeri.values())) < len(dizionario_numeri) #check for a tie

president = max (electoral_votes, key = electoral_votes.get)

if president >= 270: #absolute majority, no tie
            print (‘the new President-elect is name_candidateone’)

elif tie: #a tie occured
            involved = {chiave: valore for chiave,
```

```
                        valore in dizionario_numerico.items()
                        if list(dizionario_numerico.values()).count(valore) > 1}

            involved_candidates = [key for key, value in involved.items()
            print(f"A tie occurred between: {', '.join(involved_candidates)}")

else: #no absolute majority, no tie
            return president = False
```

4 – ELECTRONIC VOTING IN THE U.S.A.

The last part of the thesis offers a brief compendium of the main electronic voting technologies alongside their benefits and issues.

4.1 – Main and experimental electronic voting technologies

The United States employs a variety of electronic voting systems across its states and local jurisdictions. Decisions regarding the selection of technologies, their utilization, and management are typically outlined within the state's legal framework, enshrined in the state's statutory code. These systems have evolved over the years and can be broadly categorized into several types:

Direct Recording Electronic (DRE) Machines

In the 1970s, Direct Recording Electronic (DRE) voting systems made their debut[18], resembling electrical adaptations of mechanical lever machines. These early systems used push buttons and electronic storage devices. Over time, DREs evolved into portable computers with various interfaces, including touchscreen, pushbutton, or dial options, enabling voters to input their choices directly into computer memory. To enhance accessibility, Audio-Tactile Interfaces (ATI) were integrated, catering to individuals with disabilities through features like reading the ballot aloud.

[18] Claire De Soi, *MEDSL Explains: Voting Technology*, MIT Election Lab, https://electionlab.mit.edu/articles/medsl-explains-voting-technology

The evolution of voting systems continued with the increasing sophistication of computer technology in the late 1990s, leading to the development of Direct Recording Electronic (DRE) systems[19].

DRE systems allow voters to mark their votes directly into an electronic device, using touch screens, push buttons, or similar interfaces. The need for paper ballots is eliminated, as voting data is stored electronically on devices such as computer hard disks, portable diskettes, CD-ROMs, or smart cards. Some systems create redundant copies of voting data for backup and verification purposes[20].

After voting, the centralization of data occurs in a central computer, where vote totals are calculated. Data transmission to the central computer can happen through removable portable devices like diskettes or computer networks. The 1990s also saw the use of telephones as a form of DRE voting system, allowing voters to record votes directly into computer systems using keypad inputs and Personal Identity Numbers (PINs).

The modern DRE landscape showcases a range of user interfaces, with touchscreen, pushbutton, or dial options. Accessibility is further addressed with the integration of Audio-Tactile Interfaces (ATI), facilitating features such as reading the ballot aloud through headphones or utilizing paddles and sip-and-puff devices for those with dexterity impairments.

The storage of voter selections in DREs utilizes memory cartridges, diskettes, or smart cards. Some systems incorporate Voter Verified Paper Audit Trail (VVPAT) printers to enhance transparency. These printers enable sighted voters to confirm their choices on a separate paper record before the votes are officially recorded in computer memory. Depending on state election regulations, the paper record may be retained and accessible in the event of an audit or recount.

Despite these advancements, concerns linger about the security of DRE machines[21], particularly regarding potential vulnerabilities to hacking or tampering. The inclusion of a VVPAT serves as a valuable countermeasure, providing a physical record for verification purposes. The ongoing debate surrounding DRE machines revolves around finding a balance between the efficiency and accessibility offered by electronic voting and the imperative for robust security measures to safeguard the integrity of the electoral process.

[19] Aceproject, *Direct Recording Electronic (DRE)*, https://aceproject.org/ace-en/topics/et/eth/eth02/eth02b/eth02b2
[20] Verified Voting, *Voting Equipment*, https://verifiedvoting.org/votingequipment/
[21] Charles Stewart III, *Voting Technologies*, Annual Review of Political Science, https://www.annualreviews.org/doi/10.1146/annurev.polisci.12.053007.145205

Ballot Marking Devices (BMDs)

Ballot Marking Devices (BMDs) are computerized devices that display a digital ballot, allowing voters to make selections and then producing a paper record of the voters' choices. These devices can be equipped with accessible user interfaces, serving as essential assistive technology for voters who may be unable or uncomfortable marking a paper ballot by hand[22].

In contrast to Direct Recording Electronic (DRE) systems that directly store votes in computer memory, BMDs do not retain any lasting record of the voter's selections beyond the paper ballot. Some BMDs mark pre-printed ballots, while others generate summaries of voter choices, often encoding them in barcodes or QR codes. Following this process (except in hybrid systems described later), voters either submit their ballots through a separately hand-fed optical scanner or deposit them into a central ballot box for counting.

The development of BMDs was driven by the federal mandate outlined in the Help America Vote Act of 2002 (HAVA)[23], which required all polling places to facilitate private and independent voting for individuals with disabilities. In response to this mandate and to enhance usability, BMDs support private, independent voting by providing features such as screen contrast adjustment, large text, Audio-Tactile Interfaces (ATI), headphones for having the ballot read aloud, or specialized input devices like paddles or sip-and-puff devices for voters with dexterity impairments. The initial BMDs, including the AutoMARK (acquired and produced by ES&S) and Unisyn's OpenElect OVI-VC, were developed to fulfill these needs. Moreover, New Hampshire and Oregon have introduced their unique ballot marking systems. Beginning in 2014, certain jurisdictions started providing BMDs for use by all in-person voters, a trend that became widespread in 2020[24].

It is important to note that security concerns exist with these technologies, including challenges in auditing and high associated costs.

[22] *Office of the Minnesota Secretary of State*, https://www.sos.state.mn.us/elections-voting/election-day-voting/ballot-marking-machine/

[23] Congress of the USA, *Help America Vote Act of 2002*, https://www.congress.gov/107/plaws/publ252/PLAW-107publ252.pdf

[24] Verified Voting, *Voting Equipment*, https://verifiedvoting.org/votingequipment/

Remote Ballot Marking Systems

States or counties offer remote ballot marking systems to eligible voters, enabling them to access and mark their ballots through a web browser. Voter authentication usually involves entering personal information, a PIN, or a temporary password. With client-side systems, voters use their computers or tablets to access and mark the ballot locally in their browsers. In contrast, server-side systems rely on a remote server to mark and store voter selections, transmitted from the voter's computer to the server over the internet[25].

The most common way to implement remote ballot is via internet. The late 1990s witnessed the explosion of the Internet and the World Wide Web, prompting speculation within and beyond electoral administrations about leveraging this new public resource to enhance the efficiency, effectiveness, and legitimacy of democratic elections. Subsequent discussions spurred the development of studies and experiments across various jurisdictions, yielding mixed results. The consensus that emerged highlighted the multitude of risks associated with Internet Voting, underscoring the need for thorough addressing before widespread deployment.

By simplifying electoral participation to a process as straightforward as logging into a website, checking boxes on a form, and clicking "Vote," there's potential for a significant boost in voter turnout, consequently enhancing overall result legitimacy. Moreover, the adoption of internet voting could lead to substantial cost savings in deploying and operating physical polling stations, assuming a sufficiently high adoption rate. The rapid and straightforward counting of electronic ballots compared to traditional paper-based or optical-scan ballots could also result in significant cost efficiencies[26].

However there are also risks related to internet voting such as pervasive client-side malware, targeted DoS attacks and the Absence of a directly voter-verifiable ballot of record[27].

[25] Verified Voting, *Voting Equipment*, https://verifiedvoting.org/votingequipment/
[26] Aceproject, *Electronic Voting Systems*, https://aceproject.org/ace-en/topics/et/eth/eth02/eth02b/eth02b2
[27] R. Michael Alvarez, Mike Garcia, Josh Benaloh and Others, *Working Group Statement on Developing Standards for Internet Ballot Return*, University of California Berkeley, https://csp.berkeley.edu/wp-content/uploads/2022/12/Working-Group-Statement-on-Internet-Ballot-Return.pdf

Optical Scan Systems

Optical scan ballot tabulators, also known as optical scanners, come in two types: hand-fed and batch-fed scanners. In jurisdictions utilizing these scanners, voters express their choices by marking an oval, completing an arrow, or filling in a box on their ballot. Alternatively, some voters may use a Ballot Marking Device (BMD), which encodes selections into QR codes or bar codes. The ballots are then processed using hand-fed optical scanners in polling places or collected in a ballot box for scanning at a central location, either on hand-fed or high-speed batch-fed optical scanners. Larger jurisdictions typically have one or more batch-fed optical scanners centrally located to efficiently scan and tabulate mail or absentee ballots.[28]

The optical scanning devices are equipped with specialized computer hardware and software. The hardware captures an image, and the software converts this image into computer-readable data.

In the case of machine-readable ballots, voters receive a ballot card with candidates' names and corresponding symbols (such as rectangles, circles, or incomplete arrows). To indicate their choice, voters fill in the appropriate shape next to their chosen candidate.

Following the voting process, the voter can either directly feed the card into a computer vote tabulating device at the polling place or place it in a ballot box. Cards in the ballot box are later transported to a central location for tabulation. The computer tabulating device identifies the marked choices on the cards and records the votes accordingly. Individual votes are then stored in a database and aggregated to provide total results.[29]

Electronic Poll Books

Electronic poll books, commonly referred to as e-poll books, play a crucial role in modern voting systems. These digital tools come in various forms across the market, often customized by different jurisdictions to meet specific needs. Primarily, e-poll books offer multiple functions to enhance the efficiency and accuracy of the voting process.

One key feature of e-poll books is the electronic sign-in capability for voters, eliminating the need for traditional paper rosters. This electronic sign-in process not only streamlines the check-in process but also enables real-time updates of voter history. Additionally, e-poll books empower poll workers to redirect voters to the correct polling place promptly, minimizing errors associated with misdirected voters[30].

[28] Aceproject, *Optical Scanning Systems*,https://aceproject.org/ace-en/topics/et/eth/eth02/eth02b/eth02b2
[29] Verified Voting, *Voting Equipment*, https://verifiedvoting.org/votingequipment/
[30]Verified Voting, *Voting Equipment*, https://verifiedvoting.org/votingequipment/

[31]The integration of driver's license scanning further enhances accuracy by pulling up voter information without the risk of data entry errors. This technology proves beneficial in jurisdictions where electronic poll books allow poll workers to access information for voters across the entire county or state, reducing check-in time and addressing a bottleneck in the voting process.

In recent times, electronic poll books have gained prominence over paper alternatives, with many jurisdictions opting for their use. Some areas develop their own e-poll book software tailored to specific requirements, often running on readily available hardware such as laptops or tablets. Troubleshooting and maintenance of in-house systems typically fall under the responsibility of the county or state's IT staff.

Commercial electronic poll book software, provided by various companies since the year 2000, offers compatibility with a range of state voter registration databases. These commercial solutions, like their in-house counterparts, run on off-the-shelf hardware and serve the traditional functions of paper poll books. They find particular utility in early voting and Election Day vote centers that cater to voters from any precinct within a jurisdiction.

While electronic poll books offer efficiency and convenience, it's worth noting that printed paper poll books are still recommended as backups in case of unforeseen circumstances such as power outages, server issues, or malicious attacks. Overall, the evolution from traditional paper poll books to electronic systems reflects a broader trend in leveraging technology to streamline and enhance the democratic process[32].

Emerging and Experimental Technologies

The field of electronic voting is in a constant state of evolution, marked by the introduction of novel technologies and innovations. Among these are Internet voting (I-voting)[33], blockchain-based systems[34], and other emerging solutions. While these technologies show potential, they are concurrently subject to scrutiny and encounter challenges in areas such as security, accessibility, and widespread adoption.

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[32] NCSL, *Electronic Poll Books*, https://www.ncsl.org/elections-and-campaigns/electronic-poll-books

[33] France Bélanger, Lemuria Carter, *The Digital Divide and Internet Voting Acceptance*, IEEE, https://ieeexplore.ieee.org/abstract/document/5432779

[34]Sunoo Park and Others, *Going from bad to worse: from Internet voting to blockchain voting*, Journal of Cybersecurity, https://static1.squarespace.com/static/59aae5e9a803bb10bedeb03e/t/615c75f9eaae697e540f5c4f/1633449465655/VotingPaper-Rivest%2C+Narula%2C+Sunoo.pdf

4.2 – Advantages and challenges

From the preceding section, we can derive insights regarding electronic voting and its potential advantages, which could have a positive impact on the electoral system of the United States:

- **Accelerated Voting Process:** Electronic voting systems have the potential to substantially expedite the voting process. By replacing traditional paper ballots and manual vote-counting procedures, electronic machines streamline the entire process, diminishing queues and waiting times at polling stations. This not only bolsters the efficiency of elections but also encourages increased voter turnout by rendering participation more convenient.

- **Improved Accessibility:** Electronic voting systems can be customized to enhance accessibility for individuals with disabilities. These systems can integrate features like audio ballots, adjustable font sizes, and touchscreen interfaces with tactile feedback. Such accommodations empower voters with disabilities to cast their ballots more independently and confidentially, guaranteeing that their voices are heard in the electoral process.

- **Minimized Risk of Human Errors:** A significant advantage of electronic voting is the eradication of manual vote counting. Traditional paper-based systems are prone to human errors, such as miscounts or mishandling of ballots. Electronic voting mitigates these risks, heightening the accuracy and reliability of election results. This, in turn, strengthens public trust in the integrity of the democratic process.

Nevertheless, electronic voting also introduces a set of challenges and concerns that must be addressed to guarantee the security and fairness of elections:

- **Cybersecurity Concerns:** The growing dependence on electronic voting systems has heightened cybersecurity concerns. The apprehension of electoral tampering and intrusion by malicious actors is a significant issue. Ensuring the safeguarding of electronic voting infrastructure against cyber threats is a paramount concern, necessitating robust security measures and continuous monitoring.

- **Risk of Technical Malfunctions and Data Loss:** Electronic voting systems are susceptible to technical glitches and malfunctions, ranging from software errors to hardware failures. These disruptions have the potential to undermine public confidence in the electoral process. Comprehensive testing, maintenance, and the implementation of backup plans are essential to minimize these risks.

- **Digital Divide:** The adoption of electronic voting technologies may unintentionally widen the digital divide. Certain communities, especially those with limited access to technology or digital literacy, may encounter barriers to participating in the electoral process. It is imperative that efforts are made to ensure equitable access to electronic voting methods, thereby safeguarding the principle of equal suffrage for all citizens.

4.3 – Electronic Voting and the 2024 Presidential Elections

On November 5 2024 Donald Trump was elected as 47th President of the United States. Over the years in between the 2020 and 2024 elections he and other well-renowed supporters like Elon Musk have been claiming without evidence that the 2020 elections were rigged, with a particular focus on electronic voting machines, which were considered unreliable[35].

However, these allegations lack any substantiated evidence. Not only has there never been a confirmed case of tampering, but all electronic voting machines are required to undergo rigorous testing and certification by state officials. Moreover, the majority of voting technology in use today is relatively straightforward and limited in scope. Except for specialized machines designed for voters with disabilities, most voting technology serves primarily to count votes from paper ballots, with no advanced software features or network connectivity, which makes securing these systems simpler. For instance, ClearCast computer scanners—a widely used ballot-counting system from Clear Ballot Group Inc., a leading industry provider—incorporate several robust security measures[36]:

- The machine arrives at the voting site sealed and can only be opened and set up by both Republican and Democratic officials.
- Data is stored across three redundant drives, including two secured USB sticks. Any interaction by poll workers, such as the removal of a drive, is recorded in an onboard log, similar to an airplane's black box.
- Each machine logs all actions performed and can produce a daily summary for auditing.
- The machines have no Wi-Fi, Bluetooth, or network connectivity, making physical access the only means to tamper with them.

Moreover, electronic voting security measures continue to advance, with ongoing research exploring the potential of AI to enhance election integrity. For instance, AI could be utilized to detect tampering patterns, adding an extra layer of integrity to the process[37].

[35] Zachary Wolf, *How we know voting systems are secure*, CNN, https://edition.cnn.com/2024/11/04/politics/voting-systems-security-what-matters/index.html
[36] Austin Carr, *How US Voting Machines Became Safer Than Ever*, Bloomberg, https://www.bloomberg.com/features/2024-us-voting-machines-clear-ballot/
[37] Capital Technology University, *Voting Technology: How New Tech is Being Used in the Election Process*, https://www.captechu.edu/blog/voting-technology-how-new-tech-being-used-election-process

While technology can enhance the security of elections through electronic voting machines and algorithms designed to represent, execute, and manage the process automatically, a critical risk remains: misinformation. As highlighted in this paragraph, misinformation has the potential to undermine any initiative and the electoral system itself. Together with polarization—though not directly addressed in this thesis—misinformation represents one of the most significant internal threats to Western democracies. Therefore, it is essential to consider these challenges when developing election-related technologies or algorithms.

5- CONCLUSIONS

From the crafting of this thesis a key takeaway has been exercising the translation of legal procedures into a coherent series of steps guided by algorithmic logic. In times where ICT blend with every aspect of society, the proficiency in algorithmic thinking and writing stands out as a central topic in the field of laws and policy making.

Furthermore, significant insights have been gleaned into the political system and culture of the United States, discernibly shaping the European one. Additionally, a more comprehensive understanding of the main electronic voting machines, which hold the potential to enhance the accessibility and efficiency of the voting process, has been acquired.

It's worth remember that the algorithm developed in this thesis doesn't represent the whole electoral process, it only resembles the part of the process outlined in the XII Amendment but the electoral vote tie breaking procedure (the voting session in the House of Representatives). Moreover, in the implementation some informations are pre-defined, as it wouldn't have been feasible to realize a full and extremely detailed implementation in this place.

Nevertheless, the thesis algorithm stands as a glance of how the legal writing could benefit from algorithmic writing, augmented by a general knowledge of the USA President electoral process and the main electronic voting machines. It is not a definite answer, but at least it helps define what we're talking about when trying to answer the original question "How can algorithmic thinking enhance legal writing?".

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