Robotics and Computer Vision in the Brazilian Electoral Context: A Case Study

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Abstract: Since 2000, Brazil has had fully computerized elections using electronic ballot boxes. To prove the functioning and security of electronic ballot boxes transparently, some tests are carried out, including the integrity test. This test is carried out throughout the national territory in locations defined for each Brazilian state, with a reasonable number of people. Here, an automation system for integrity testing is presented, consisting of a robotic arm and software using computer vision for the two versions of electronic ballot boxes used in the 2022 presidential elections. Two days of tests were carried out, simulating the integrity test in the laboratory and a test during the real integrity test of the 2022 election. The system managed to cast between 197 and 232 votes during the tests with an average vote time of between 2 minutes and 15 seconds to 2 minutes and 43 seconds, depending on the version and test day, and errors between 1.48% and 3.72%, including reading and typing errors. The system allows you to reduce the number of people per electronic ballot box and increase the transparency and efficiency of the integrity test.

1 INTRODUCTION

The electoral process in Brazil covers all the stages involved in organizing elections, followed by a short post-election period. The Electoral Justice is responsible for organizing, overseeing, and conducting elections, regulating the electoral process at federal, state and municipal levels. It has a supreme body, the Superior Electoral Court (TSE), headquartered in the country's capital, Brasilia. In addition to the TSE, each state and Federal District has a Regional Electoral Court (TRE), along with judges and electoral boards (Court, 2022e).

To ensure the normality of the elections, the security of the vote and democratic freedom, the Brazilian electoral system employs numerous mechanisms, such as electronic ballot boxes and biometric voter identification, making it a global reference. In the 2022 elections, 577,000 electronic ballot boxes were used (Court, 2022g), distributed across 5,570 municipalities in Brazil and 181 cities overseas (Court, 2022f), with more than 123 million Brazilians able to exercise their right to vote (Court, 2022d).

The electronic ballot box is a specialized microcomputer designed for electoral use. It has two terminals: the polling station and the voter's terminal. In the former, the polling officer identifies the voter and a built-in biometric reader is used to confirm the voter's identity. The latter is where the vote is recorded and comprises a memory device for storing the votes, a numeric keypad, and a liquid crystal display screen (Court, 2022c).

To ensure the fairness of the electoral process, a series of tests are conducted on the electronic ballot box, including the integrity test, which is used to validate its security and functionality. In every election in Brazil, the Electoral Justice conducts this type of audit. This process compares the votes cast on paper ballots with those entered into the electronic bal-

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lot box (Court, 2022b). In the first round of the 2022 elections, 641 electronic ballot boxes were audited across Brazil (Court, 2022h).

The system presented here was developed to automate the entire integrity test of the electronic ballot boxes in the 2015 and 2020 versions, as they were used in the last election. It consists of a robotic arm, application software, information extraction from the paper ballots, and some customizations, requiring only one operator per system.

In addition to this introductory section, the article is divided into five other sections: “Contextualization of the Problem”, which contains a detailed description of how the integrity audit process of electronic ballot boxes functions; “Related Works”, which includes some articles where authors have used robotic arms to automate software testing; “Automation System for Integrity Testing of Electronic Ballot Box”, which describes all parts of the presented system; “Tests and Results”, which contains the tests conducted in the laboratory and real-world situations; and “Conclusion”.

2 CONTEXTUALIZATION OF THE PROBLEM

The integrity testing of electronic ballot boxes begins one day before the elections. The polling stations from which the voting machines will be collected for the integrity test are selected through a random draw. The number of polling stations selected varies between 6 and 33, depending on the number of polling stations per state and the voting round (Fachin, 2021). These voting machines are removed from their original municipalities, replaced with new equipment, and installed in a monitored location with a significant presence of people, as indicated by the Regional Electoral Tribunal of each state. Representatives from political parties, the Brazilian Bar Association (OAB), the Public Prosecutor’s Office, other oversight entities, and interested citizens participate in this process (Court, 2022b).

Some paper ballots are filled out for each selected voting machine, ranging from 75% to 82% of the number of registered voters in the respective polling station (Sansão, 2018). Representatives from political parties, federations, and coalitions participate in this process. If they do not appear, third party will fill out the ballots, excluding Electoral Justice staff (Court, 2022a). A list of candidates to be voted on at the selected polling stations is available to fill out paper ballots by hand in addition to party votes, blank votes and invalid votes and are then deposited in canvas ballot boxes. On the day of the test, these ballots are entered into a digitizing system on a computer, which is used for tallying and digitizing the votes. Subsequently, they are printed on paper ballots. The audit work takes place on the same day and at the same time as the regular election, from 08:00 AM to 05:00 PM. After issuing the ”Zeresima” report, which certifies that no votes were counted before the start, issued by the voting machine and support system, the procedures are initiated (Court, 2022a).

Each voting machine involves four individuals in the auditing process: the verifier, the data entry operator, the enabler, and the voter.

- The verifier retrieves the ballot from the canvas ballot box and checks its validity. The valid ballots are labeled with a sequential vote number. In the case of a blank ballot, “EM BRANCO” (portuguese for “BLANK”) is stamped next to each space.
- The data entry operator selects a valid voter ID and enters it into the auxiliary system. They compare the sequential number labeled on the ballot with the one displayed in the auxiliary system and input the votes from the ballot into the auxiliary system. They verify what has been entered with what is on the ballot and then file the voted ballot. The vote remains on the monitor of the auxiliary system until the voter completes the process on the electronic ballot box.
- The enabler activates the voter, enters the polling station and places their fingerprint if necessary. Then, the voting machine is enabled for the voter.
- The voter enters each digit of their vote into the voting machine, announcing it aloud for recording in the video. For each position, the candidate’s name indicated by the voting machine is announced, and after entering, there is a 3-seconds wait before confirming the vote (Court, 2022a).

At the closing time of voting, at 05:00 PM, the integrity test is also concluded, even if only some of the ballots have been entered. The Ballot Box Report (in portuguese, ”Boletim de Urna” or ”BU”) is printed with the totalized votes to provide a physical record of the results (Court, 2022a). A storage medium continuing the results is removed from the voting machine, inserted into the computer and the system generates a comparative report between the BU and the ballots entered in the support system.

If the results match, a closing report will be prepared. However, suppose there is a discrepancy between the BU and the support system’s report. In that case, the discrepancies will be identified, and the entries on the respective ballots will be checked based on the timestamp and video recordings. If the discrepancy persists, all the entered ballots must be reviewed, and a detailed record of all discrepancies, even those resolved, will be made in the report (Court, 2022a).

3 RELATED WORKS

Robotic arms offer a method for simulating user interactions with touch screens and device movements, enhancing the precision and accessibility of software testing. This automation enables scenarios difficult for humans and ensures consistent testing over extended movements.

In (Banerjee and Yu, 2018b), a six-axis articulated robot automates tests on facial recognition software for mobile phones. The robotic arm facilitates precise positioning of phones, varying camera tilt angles, and simulating real-world scenarios like device shaking, enhancing algorithm testing for accuracy, functionality, stability, and performance.

(Banerjee et al., 2018) applies a robotic arm to automate tests for image rectification software, improving efficiency and scalability by reducing the need for manual testing. Specific lighting and safety conditions are implemented for better coverage of configuration variations.

(Frister et al., 2020) proposes using an industrial robotic arm to test Android mobile applications, equipped with a capacitive stylus for consistent and repetitive touchscreen tests. This approach detects errors or unexpected behaviors, ensuring high precision and scalability in testing scenarios.

In (Banerjee and Yu, 2018a), a robotic arm automates tests in a motion-based image capture system, demonstrating superior performance in image capture latency, relative motion measurement, and precision compared to third-party solutions.

These studies showcase diverse applications of robotic arms in software testing, emphasizing precision, consistency, and scalability. Considering this technology for electronic ballot box integrity testing could offer an innovative and practical approach to enhance the security and reliability of the electoral process.

4 AUTOMATION SYSTEM FOR INTEGRITY TESTING OF ELECTRONIC BALLOT BOXES

The proposed system aims to automate the integrity test. It will extract the voter ID and votes from the paper ballot and input them into their respective terminals, the polling station, and the voter's terminal, following the order of political positions. The system consists of three main units: the robotic arm Kinova Gen3 lite (Kinova, 2020), the application software, and the module for extracting information from the paper ballots. In addition to these units, customizations and the automation flow of the integrity test are presented.

4.1 Application Software

The application software serves as the system's user interface with the robot and acts as a repository of information through the database. Consequently, it allows interaction and handles possible issues, such as forgetting to change the paper ballot. This system part can be subdivided into frontend, backend, and database components.

4.1.1 Frontend

The frontend was developed using Flutter, a cross-platform framework developed by Google (GOOGLE, 2017). Initially, the user selects the robot model to be connected and the model of the electronic ballot box to be audited, either 2015 or 2020. This connection is established via socket, and these choices can only be made if the server (backend) is online. The application offers four ways to interact with the robot and the electronic ballot box: manual voting, batch voting, OCR voting and assistive voting.

In manual voting, the user manually enters the voter ID and each vote through the application, using an interface similar to the electronic ballot box. This feature was developed to allow voting using the keyboard. In batch voting, which is used in the automation of the integrity test, the user has the option to initiate the automation of votes. They are responsible for changing the paper ballots on the template, given the robot remains in a loop: extracting information from the paper ballots, performing the release of the terminal and voting on the electronic ballot box for each new paper ballot. In OCR voting, compared to batch voting, the user needs to verify each captured image as well as the information extracted from these images in each execution.

In assistive voting (da Silva Mendonça et al., 2023), a head mouse, with the help of a camera, is used to assist individuals with reduced mobility while ensuring the secrecy of their votes. With eye movements, the user can move the cursor to the necessary positions to cast their vote, and blinking eyes serves as the click action. The interface for this method is designed to resemble the electronic ballot boxes interface closely.

Batch voting also has some exceptions that the user manually handles. Visual feedback is provided when a paper ballot returns an error during the reading process or if the user forgets to change the paper ballot. The application displays a message for checking the paper ballot's position or indicates that the paper ballot has already been read.

4.1.2 Backend

In the backend, the connection with the robot is established via a socket on a localhost server. All information that arrives from the extraction unit, after passing through the backend, is sent to the robot. Each movement is executed by extracting the information obtained from manual mapping contained in a .json file for each position. In the backend, adjustments are also made for the arm's movement time in relation to the type of voter because there are voters with registered fingerprints and those without, as well as other exceptions that do not follow the standard flow, such as visually impaired individuals.

The image of the paper ballot captured by the camera on the robotic arm is sent to the backend, where all the information is extracted, as will be explained in the section 4.2. All extracted votes and voter ID are saved in the database along with the insertion timestamp, as will be described in the 4.1.3 section.

4.1.3 Database

The system's database was developed using MySQL due to its ease of understanding, scalability, security, and multi-platform support. The database serves two main roles: assisting in data retrieval and guiding the voting flow. Since the integrity test is conducted with voters from a fictitious electoral section, access to all voters in that section is provided. Initially, the database is populated with biometrics recognition, voters without biometrics, and voters with visual impairments. These variations lead to different voting flows in the electronic ballot box.

During the experiments, the database stores the voter ID, votes and timestamps. This allows checking if the voter ID is extracted from the paper ballot, otherwise the robotic arm will not attempt to enable the same voter to vote again, thus avoiding time loss. At the end of the voting process, the information from the database is compared with the information on the election results report to ensure the integrity of the votes. Verification is also carried out with the vote recording media inside the electronic ballot box.

4.2 Information Extraction from Paper Ballots

The methodology proposed by (Silva et al., 2023) was followed, which was developed in conjunction with our system. It is based on Optical Character Recognition (OCR) and its application in the context of automating integrity tests in Brazilian elections.

Using YOLOv4 (Bochkovskiy et al., 2020), two regions of interest are cropped - one with the voter ID and another with the votes, highlighted in red in Figure 1. Then, EasyOCR (Awalgaonkar et al., 2021) is used for information extraction. After extracting the information from the paper ballots (voter ID and vote numbers), the processing is performed to correct possible extraction errors, such as reading errors when EasyOCR cannot extract the voter ID information correctly or ballot misplacement errors when the paper ballot is not correctly positioned in the physical template. Then, the extracted information is sent to the system's backend, allowing the voting process to continue.

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Cédula: 1 - Hora: 00:00:00		Título: 010321032097 - Ano: 0000	
Cargo	Tipo	Candidato	Votado
Deputado Federal	Nominal	GARÇOM	9303
Deputado Estadual	Nominal	FOLIA DE REIS	94001
Senador	Nominal	MÚSICA ELETRÔNICA	921
Governador	Nominal	SAMBA	92
Presidente	Nominal	FORRÓ	92

Figure 1: Voting ballot.

4.3 Personalizations

Before starting the process, obtaining the spatial position of all points where the robotic arm needed to move was necessary. Using a joystick to control the robotic arm's movement and a Python code to monitor the joint values, the values of the six joints for each position were obtained. These values were recorded in a Google Sheets spreadsheet and then transformed into a .json file that the software could read.

The mapped positions included the keys on the presiding polling station, the keys on the voter's terminal, and the position for reading the paper ballot. All of these positions have safety positions to ensure safe arm movement. Each key has two positions, one slightly above the key and another with the key pressed.

To ensure correct positioning, a template was created to ensure the positioning of the terminals, the ballot box, and the paper ballot with reference to the robotic arm. This template was created using a 3D printer, as shown in figures 3 and 4.

In addition to the template, two other 3D-printed parts were developed. One is a base for a silicone finger that minimizes the effort exerted on the keys of the 2015 version of the voter terminal and the officer terminal. For the 2020 version, which has a touch screen, the silicone finger is covered with a finger glove made of silver mesh and elastane, which has a USB cable connected to the robot's base, allowing the robotic arm to interact with the touch screen by generating static electricity caused by the contact of the glove and the USB cable. Finally, a support was designed and printed to attach the camera to the robotic arm. These parts are shown in Figure 2.

Figure 2: Camera stand and silicone finger.

4.4 Automation Flow

The robot (with a camera and silicone finger) is initially secured to the table, and the assembly of the template is performed. Each terminal is placed in its respective position, and the key positions are obtained and saved in a .json file. The model of the voting machine and the type of robot used in the system are selected.

With the start of the integrity test, a voter ID is entered into the auxiliary system along with the votes that were preveiusly filled out, just as is done in the non-automated process. A ballot containing the votes and the voter ID is printed and placed in its corresponding position on the template. The user initiates the batch voting, and the robot moves to the reading position for the ballot, as shown in Figure 3. An image of the ballot is obtained, and all necessary information is extracted. Suppose the system cannot extract the necessary information. In that case, a warning will be displayed on the system's frontend, prompting the user to check the position of the ballot, as they may have forgotten to place a ballot or some other external factor that may be hindering the system's ability to extract information. If the extraction is successful, it checks whether the voter ID is already in the database. If the user forgot to change the ballot, a warning is displayed on the system's frontend, instructing the user to change the ballot. If the voter ID is not already in the database, it checks the type of voter in the database to determine the flow, as it varies according to the type of voter.

Figure 3: Electronic ballot box test 2015.

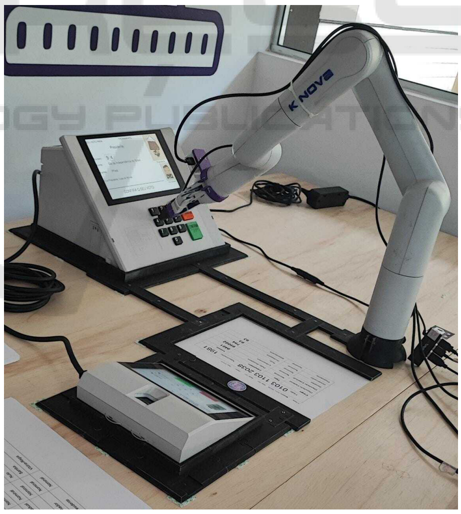

Figure 4: Electronic ballot box test 2020.

The robot types the extracted voter ID into the polling station and activates the voter's terminal. Subsequently, the robot will type each vote extracted from the paper ballot into the voter's terminal, as shown in Figure 4. Upon completing the votes for that voter ID, the information is saved in the database, and the robot returns to the ballot reading position to initiate a new voting cycle.

When the robot initiates the voter ID typing pro-

Table 1: Test Analysis.

Model-day	**2015-01**	**2015-02**	**2015-03**	**2020-01**	**2020-02**	**2020-03**
Total time	9 h	9 h	8 h 53 min	8 h 47 min	8 h 22 min	8 h 53 min
Quantity of votes	225	225	197	232	223	197
Average time per vote	2 min 24 s	2 min 24 s	2 min 43 s	2 min 16 s	2 min 15 s	2 min 43 s
Eletronic Ballot Box inspections	7	6	6	4	4	4
Reading errors	10	10	2	3	12	4
Ballot exchange error	0	2	0	3	0	0
Typing errors	0	0	3	1	1	1
External error	0	0	0	1	0	0

cess, the user can begin entering another voter ID with votes into the auxiliary system, print it, and replace the read ballot with this one to continue the process. In case of any issue during the process, the user can pause the system and resume from where they left off. Figure 5 provides a more visual representation of the entire flow.

5 EXPERIMENTS AND RESULTS

The experiments were conducted to simulate a real integrity test. Two days of testing were performed for each electronic ballot box model, 2015 and 2020. For these two days of testing, the robots were set up in a central area of the audit to have more visibility, and with a single system operator, we were able to use two robotic arms to audit two electronic ballot boxes, one of the 2015 model and the other of the 2020 model, simultaneously, reducing the required workforce from six people to one per shift (morning/afternoon). 235 ballots were used with voter IDs registered in the electronic ballot box training software and with votes randomly generated among fictitious candidates.

Three problems may occur during the experiments that require user interaction with the system. The first is when the extraction system cannot extract the voter ID, either because there is no ballot, which occurs when there is no paper ballot in the template, or because the lighting is inadequate, which happens when the camera cannot obtain the ballot's information due to occlusion or shadow. The second is when the ballot is not changed due to an operator error who did not change the ballot in the template. The last one is when the voter machine inspection process occurs. This inspection is already part of the process, occurs randomly, and serves for the election worker to check if the voting machine is working correctly. The worker performs quick procedures on the terminal and the voting machine to release the next voter.

Table 1 contains all data related to all the experiments conducted in the laboratory (day's 01 and 02) and on day of the real integrity test On October 2, 2022 (day 03). The first row categorizes the electronic ballot box model and the day of the test. The total time corresponds to the period the system spent voting from the first ballot to the last. The quantity of votes is the number of ballots read and voted without errors. The average time per vote is the relationship between the total time and the quantity of votes. This value also includes the first time-electronic ballot box inspection errors. The next three rows represent the number of errors corresponding to the errors that required user interaction with the system, as described in the previous paragraph.

The 2020 model had an average time per vote of 2 minutes and 16 seconds on the first day and 2 minutes and 15 seconds on the second day. For reading errors, out of a total of 940 readings, there were only 35 errors, which represents 3.72%. Since the 2020 model has a touchscreen ballot terminal, there was a typing error each day in which it registered two clicks on the same number. An unforeseen error occurred during the experiments where the electronic ballot box test software crashed and needed to be restarted on the first day of the 2020 model. Additionally, in the 2020 model, there is a slight discrepancy in the number of votes cast between the first and second day. This occurred due to a particular error in which some ballots with many leading zeros before voting ID (Ex: 0000.0076.8762) could not be read on the second day of testing. Therefore, the total time was reduced because fewer ballots were successfully read.

On "day 03" the system was run on two electronic ballot boxes, models 2015 and 2020, at the designed integrity test location. The test on that day highlighted the potential of the application, with the system only being surpassed in the number of votes by one of the twenty-seven sections audited manually, and the number of registered voters in that section was way smaller than the section that the robot arm audited. The tests on that day highlighted the potential of the application, being surpassed in the number of votes only by one of the twenty-seven sections operated by

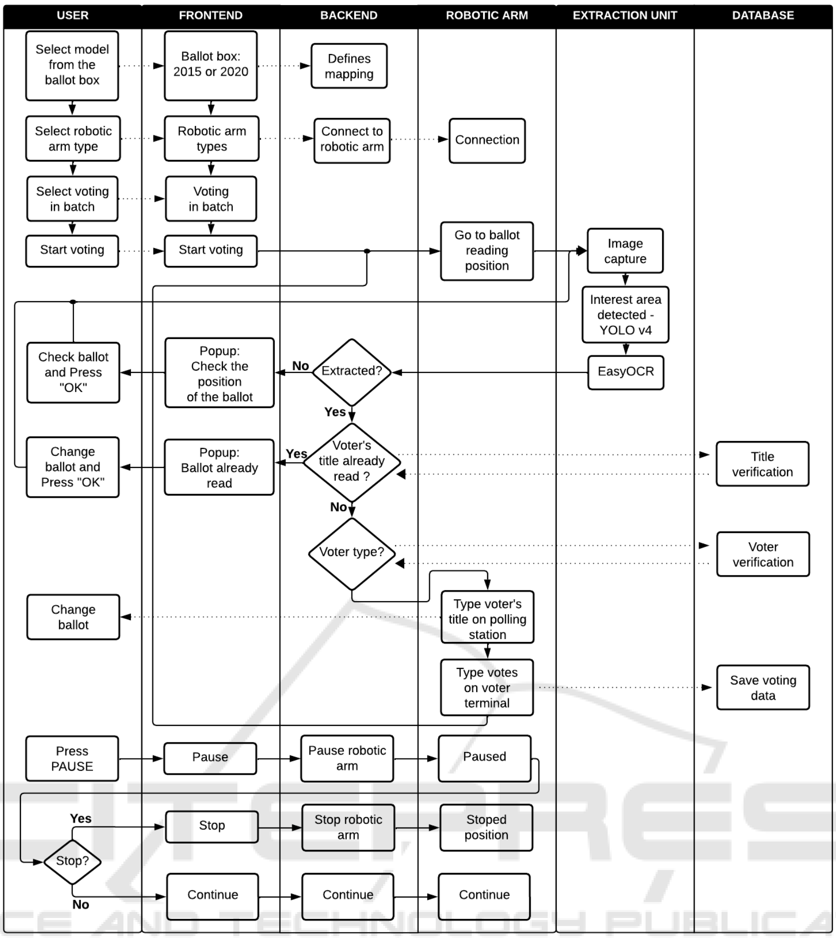

Figure 5: Flow automation.

people.

It is observed that both models took the same amount of time, 8 hours and 53 minutes, to complete the voting process, processing a total of 197 votes with an average time per vote of 2 minutes and 43 seconds. Regarding reading errors, out of 404 readings made, there were only six errors, which is 1.48%. In terms of typing errors, there are only four double-click errors. There were no errors caused by other external agents that were not mapped, nor were there any errors regarding the exchange of ballots.

6 CONCLUSION

The implementation of an automation system for electoral integrity auditing represents a significant advancement in the context of elections in Brazil. Currently, this process involves using 6 to 33 electronic ballot boxes for testing and an average of 100 people to conduct these audits, depending on the state performing the audit. This study sought to evaluate the system's effectiveness developed through laboratory tests and an integrity test conducted during the 2022 presidential elections. The results indicate that the system can handle different models of electronic ballot boxes and adverse situations, demonstrating robustness in the face of ballot reading errors.

The system provides a way to mitigate typing errors caused by inattention or fatigue, which can be highly detrimental to ensuring a clean election. In such cases, one could argue that the fault lies within the electronic ballot boxes software and not with human error, even though the entire process is recorded. It also reduces the workload on the TREs teams, who would otherwise need to review the recordings and identify why a particular error occurred. This approach can increase the number of completed votes, reduce the number of people involved in the auditing process, and make it more transparent.

As the audit is conducted across the entire Brazilian territory, there is no standard setup, leading to numerous variables that need to be addressed for an automation system, such as the issue of varying illumination. This study serves as a starting point for future research and development in the field of electoral automation, emphasizing the importance of improving audit systems to ensure the integrity of the democratic process.

As a future work, it is possible to make the automation system more secure and automated by verifying the data entered in both terminals through screen reading.

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REFERENCES

Awalgaonkar, N., Bartakke, P., and Chaugule, R. (2021). Automatic license plate recognition system using ssd. In *2021 International Symposium of Asian Control Association on Intelligent Robotics and Industrial Automation (IRIA)*, pages 394–399. IEEE.

Banerjee, D. and Yu, K. (2018a). Integrated test automation for evaluating a motion-based image capture system using a robotic arm. *IEEE Access*, 7:1888–1896.

Banerjee, D. and Yu, K. (2018b). Robotic arm-based face recognition software test automation. *IEEE Access*, 6:37858–37868.

Banerjee, D., Yu, K., and Aggarwal, G. (2018). Image rectification software test automation using a robotic arm. *IEEE Access*, 6:34075–34085.

Bochkovskiy, A., Wang, C.-Y., and Liao, H.-Y. M. (2020). Yolov4: Optimal speed and accuracy of object detection. *arXiv preprint arXiv:2004.10934*.

Court, R. E. C. (2022a). Como ocorre o teste de integridade das urnas eletrônicas. url= https://www.tre-ce.jus.br/eleicao/eleicoes-2022/auditoria-de-funcionamento-das-urnas-eletronicas/como-ocorre-a-auditoria-de-funcionamento-das-urnas-eletronicas. Accessed: 2023-09-10.

Court, R. E. S. (2022b). Auditoria dia da eleição (teste de integridade). url= https://www.tre-sp.jus.br/eleicoes/eleicoes-2022/auditoria-dia-da-eleicao-teste-de-integridade. Accessed: 2023-09-10.

Court, S. E. (2022c). Ballot box. https://international.tse.jus.br/en/electronic-ballot-box/presentation. Accessed: 2023-09-10.

Court, S. E. (2022d). Comparecimento/abstenção. https://sig.tse.jus.br/ords/dwapr/r/seai/sig-eleicao-comp-abst/home?session=204150010670548. Accessed: 2023-09-15.

Court, S. E. (2022e). Election process in brazil. https://international.tse.jus.br/en/elections/election-process-in-brazil. Accessed: 2023-09-10.

Court, S. E. (2022f). Eleitorado da eleição — estatísticas. https://sig.tse.jus.br/ords/dwapr/r/seai/sig-eleicao-eleitorado/home?session=204150010670548. Accessed: 2023-09-15.

Court, S. E. (2022g). Justiça eleitoral recebe mais de 206 mil novas urnas que serão utilizadas nas eleições 2022. url: https://www.tse.jus.br/comunicacao/noticias/2022/Junho/justica-eleitoral-recebe-mais-de-206-mil-novas-urnas-que-serao-utilizadas-nas-eleicoes-2022. Accessed: 2023-09-12.

Court, S. E. (2022h). Testes de integridade - relatórios referentes ao 1º e 2º turnos. url: https://www.tse.jus.br/eleicoes/eleicoes-2022/testes-de-integridade-relatorios-referentes-ao-1o-e-2o-turnos. Accessed: 2023-09-15.

da Silva Mendonça, F. A., Teixeira, J. M. X. N., and da Silva Júnior, M. R. (2023). Includevote: Development of an assistive technology based on computer vision and robotics for application in the brazilian electoral context. In Radeva, P., Farinella, G. M., and Bouatouch, K., editors, *Proceedings of the 18th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, VISIGRAPP 2023, Volume 4: VISAPP, Lisbon, Portugal, February 19-21, 2023*, pages 755–765. SCITEPRESS.

Fachin, E. (2021). ResoluÇÃo nº 23.674, de 16 de dezembro de 2021. https://www.tse.jus.br/legislacao/compilada/res/2021/resolucao-no-23-674-de-16-de-dezembro-de-2021. Accessed: 2023-09-10.

Frister, D., Oberweis, A., and Goranov, A. (2020). Automated testing of mobile applications using a robotic arm. In *2020 International Conference on Computational Science and Computational Intelligence (CSCI)*, pages 1729–1735. IEEE.

GOOGLE (2017). Flutter. https://flutter.dev/. Accessed: 2023-10-04.

Kinova (2020). Gen3 lite robot. https://www.kinovarobotics.com/product/gen3-lite-robots. Accessed: 2023-08-20.

Sansão, S. (2018). ResoluÇÃo nº 23.674, de 16 de dezembro de 2021. https://www.tre-ro.jus.br/legislacao/compilada/resolucao/2018/resolucao-n-06-2018. Accessed: 2023-08-10.

Silva, J., Guerra, G., Rodrigues, Y., Veloso, P., Silva, C., Souza, P., and da Silva, M. (2023). Ocrs for extracting characters from ballots in the process of automating the integrity test in the brazilian elections. *Proceedings of the Future Technologies Conference (FTC) 2023, Volume 1*.