IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13908

A Study of Electronic Voting Machines Used Worldwide

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Abstract: Voting machines play a significant role in ensuring accurate, transparent, and secure elections. This paper analyses various voting machines that researchers have proposed from time to time in their research work. The study explores technological advancements, security features, voter accessibility, transparency, usability improvements, etc. By studying several research papers/ articles, voting machines are categorized into two main categories: those that are currently used in practice and those that have been proposed in the literature but not implemented physically yet. The categories of these machines are further sub-categorized according to various technologies used The present study is based on both patent literature and non-patent literature.

Keywords: Election, Voting Machines, Internet Voting, Mobile Voting, Voting Method

I. INTRODUCTION

In democratic countries, elections are conducted to elect representatives of the people by the people and for the people. These elected representatives form the government. Eligible citizens cast their votes in elections through paper ballots or electronic machines. The machines used for voting are called electronic voting machines. This paper focuses on different voting machines used in elections. Over the years, various voting machines have been invented and implemented worldwide. This paper explores existing voting machines used worldwide. It also explores voting machines proposed by various researchers which could not be implemented. Such machines are available in the literature (patent and non-patent) only.

By reviewing a range of research papers and articles, the paper categorized voting machines into two main categories: existing machines that are operational in various electoral systems around the world and voting machines that are proposed by several researchers. Voting machines that are commonly used around the world, such as punch-card machines, electronic card machines, OMR (Optical Mark Recognition) and OCR (Optical Character Recognition) machines, and DRE (Direct Recording Electronic) machines, are discussed in the first category. In the second category, voting machines have been discussed, which were suggested by the researcher but have not yet been implemented, and these voting machines are further subdivided into card-based, biometric-based, network/ internet-based, and other technology-based voting machines.

II. RESEARCH METHODOLOGY

This paper employs a mixed-methods design, integrating both qualitative and quantitative approaches. Existing literature was studied to gather information on the types of voting machines currently in use worldwide and voting machines proposed by researchers. Relevant academic papers, technical reports, government publications, and patent literature etc. from different sources such as IDEA, IEEE Xplore, Google Scholar, etc. has been taken for the authenticity for studying voting machines.

III. LITERATURE REVIEW

Literature has found a variety of voting machines, some of which have been fully developed and are currently in use worldwide. In contrast, others are purely theoretical and have not been physically implemented. To better understand voting machines, these are classified into the categories shown in the diagram below.

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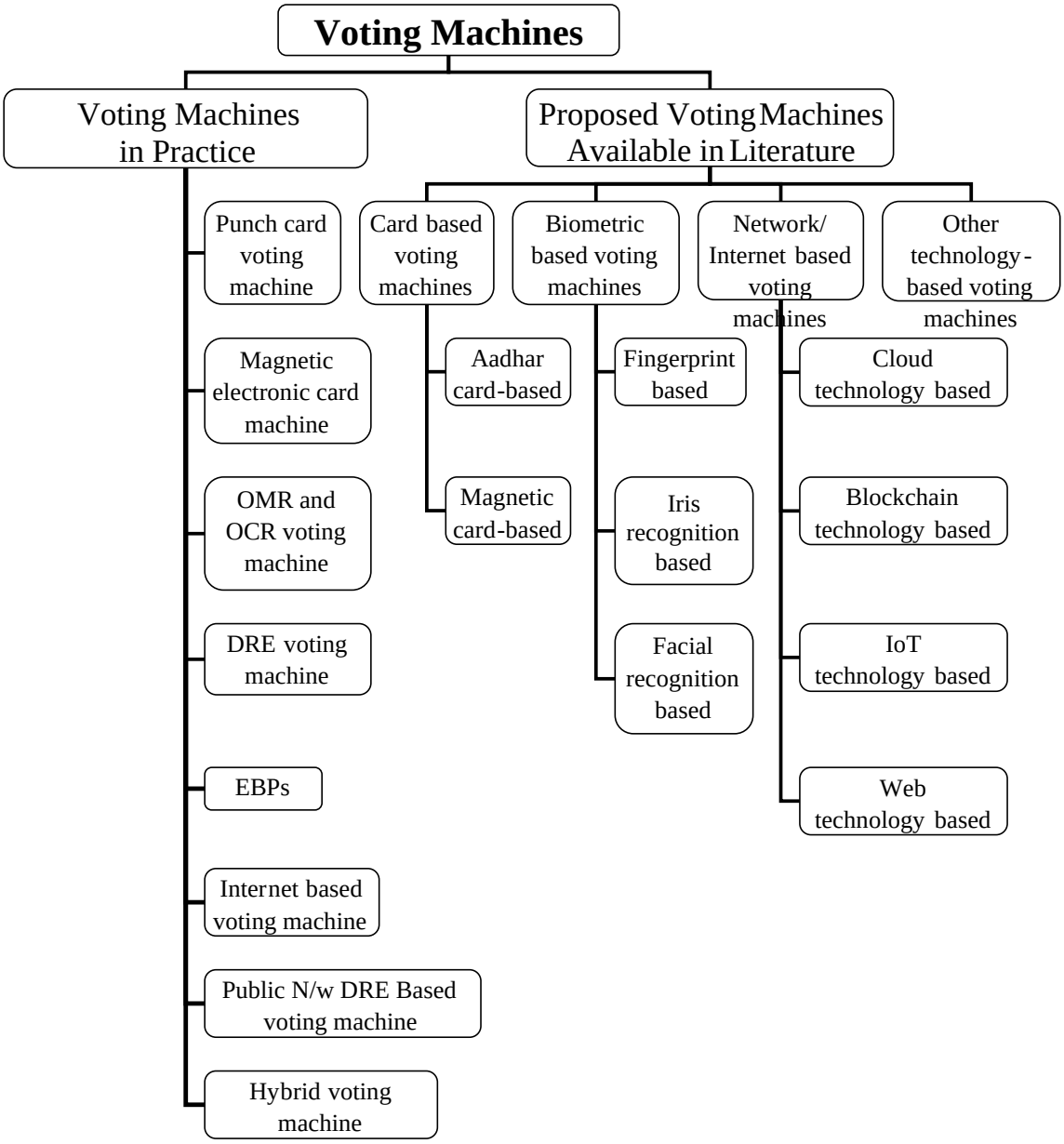

Figure 1. Classification of Voting Machines

A. VOTING MACHINES USED WORLDWIDE

Different countries use different voting procedures, voting machines, and electoral systems. In this section, the study focuses on existing voting machines in different countries, as discussed below (ACE Project., n.d.)

i) Punch Card Voting Machine: In this voting machine, a card is considered as a ballot, and a device is required to punch this card for voting. These punch cards are kept secured in the ballot box after being punched by the voter. Day of counting, these cards are counted to declare the result.

ii) Magnetic Electronic Card Machine: A magnetic card is considered as an identity or voter card in this system. All information is stored on this card. The card is inserted into the machine, and verification proceeds with the data that has already been stored.

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After verification, the ballot paper is displayed on the machine; by pressing the button, contesting candidates are chosen, and a vote is cast in favour of the candidate. Records of these votes are stored in the machine automatically, and the result is seen when required.

iii) OMR and OCR Voting Machine: In this machine, an optical mark device is used to fill the oval, box, arrow, etc., to cast votes on the ballot paper. These ballot papers are stored in the ballot box. On the day of counting, these ballots are scanned by feeding them into the scanner, and the result is produced.

iv) DRE Voting Machine: DRE stands for Direct Recording Electronic. The dialing system interface is used in the DRE machine by pressing the button and touching the screen. The cast vote or choice of voter is stored directly in the memory of the DRE machine. Votes are automatically counted in the DRE, and results are seen by pressing/ touching buttons following instructions. Indian EVM is an example of a DRE voting machine. An embedded system is used for the DRE machine. Different types of hardware, software storage, and microcontrollers are used for DRE depending on machine to machine.

v) EBP: Electronic Ballot Printers (EBPs) are also used for electronic voting purposes. The functioning of this machine is similar to the DRE voting machine. Still, the main difference is that the machine generates printed slips of choice and is stored in the ballot box. Votes can be counted by manually counting slips and machines' recorded information.

vi) Internet Based Voting Machine: In the Internet voting system, credentials are used to log into the voting portal. Verification is done using different methods such as OTP-based, fingerprint scanning, iris scanning, facial scanning, etc. After authentication and verification, the voters are allowed to cast their votes. After one vote, the voter is not allowed to cast vote again. If the voter fails during authentication, then the system will not allow the voter to vote. Voting can be done at the place of the polling station or from any place that varies from country to country.

vii) Public Network DRE Voting: This system uses the functionality of DRE and the internet voting method. Ballots can be transferred on the public network from one location to another during the election. The centralized method is used to count ballots using the Public Network DRE method.

viii) Hybrid Voting System: When two or more voting systems are used, it is considered a hybrid voting system, which is more secure and convenient. The Indian Electronic Voting Machine (EVM) is an example of a DRE system with EBPs.

A table is given below with the list of countries using machines for electronic voting. In the countries not shown in the list, either the data of countries was unavailable, or no machine was available (IDEA, n.d.).

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Country	Year	Voting Machine Used
Albania	2021	DRE voting machines with and without VVPAT
Argentina	2021	Electronic ballot printers
Armenia	2021	Internet voting systems
Australia	2022	Internet voting systems
Bangladesh	2018	DRE voting machines with and without VVPAT
Belgium	2019	Electronic ballot printers
Bhutan	2018	DRE voting machines with and without VVPAT
Brazil	2022	DRE voting machines without VVPAT
Bulgaria	2023	DRE voting machines with and without VVPAT
Canada	2019	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR) Internet voting systems
Congo, Democratic Republic of	2018	Electronic ballot printers (EBPs)
Dominican Republic	2017	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR)
Ecuador	2021	Internet voting systems
El Salvador	2024	Internet voting systems DRE voting machines with and without VVPAT
Estonia	2021	Internet voting systems
Fiji	2018	DRE voting machines with and without VVPAT Electronic ballot printers
France	2022	DRE voting machines with and without VVPAT Internet voting systems
India	2019	DRE voting machines with and without VVPAT
Iran, Islamic Republic of	2021	DRE voting machines with and without VVPAT
Iraq	2018	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR)
Korea, Republic of	2022	Internet voting systems
Kyrgyzstan	2020	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR)
Mexico	2021	DRE voting machines with and without VVPAT Internet voting systems
Mongolia	2020	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR) SMS voting systems
Namibia	2019	DRE voting machines with and without VVPAT
New Zealand	2020	Internet voting systems
Oman	2023	Internet voting systems (including mobile application)

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Panama	2019	DRE voting machines with and without VVPAT Internet voting systems
Paraguay	2021	DRE voting machines with VVPAT
Peru	2020	DRE voting machines with and without VVPAT
Philippines	2022	Optical Mark Recognition (OMR) or Optical Character Recognition (OCR)
Russian Federation	2021	DRE voting machines with and without VVPAT Optical Mark Recognition (OMR) or Optical Character Recognition (OCR) Internet voting systems
Switzerland	2023	Internet voting systems
United Arab Emirates	2019	Internet voting systems
United States	2018	DRE voting machines with and without VVPAT Optical Mark Recognition (OMR) or Optical Character Recognition (OCR) Some states allow overseas and military voter to send ballots electronically.
Venezuela	2017	DRE voting machines with and without VVPAT

Table 1: Country-wise Electronic Voting Machines

B. VOTING MACHINES NOT USED BUT AVAILABLE IN LITERATURE

Voting machines proposed by researchers in patent and non-patent literature have been discussed here. Such voting machines have been divided into four categories- i) card-based voting machines, ii) biometric-based voting machines, iii) network/ internet-based voting machines, and iv) other technology-based voting machines.

i) CARD-BASED VOTING MACHINES

a) *Aadhar card-based voting machines:*

The authors presented a paper titled "An Approach to Electronic Voting Machine using UIDAI" at a conference in Coimbatore, India. The proposed system, based on UIDAI data, consists of four stages: the Registration Stage, where data from UIDAI is uploaded to the voting server; the Electorate Information Stage, where nomination files are uploaded to the MIS portal for voter review; the Voting Stage, where voters use a mobile app to cast their votes, with the app automatically uninstalling after voting; and the Completion Stage**,** which involves sending acknowledgments to both voters and authorities. The system eliminates the need for physical voting centers, potentially increasing voter turnout (Yadav et al., 2014).

A research paper titled "Smart Voting" proposed a system based on Aadhar data and fingerprints. The system automatically issues voter cards using Aadhar information for citizens over 18. It replaces existing voting machines with new ones capable of tracking Aadhar cards to prevent duplicate voting. Online voting is facilitated through a mobile app, and digital voter IDs are generated from the admin database. The new voting machines connect to computers via USB, and voter verification is done through fingerprint and iris scanning. Only verified voters are allowed to vote, and their status is updated in the database (Bhuvanapriya et al., 2017).

The authors proposed a web-based voting system titled "Online Voting System Powered by Aadhar Authentication" to improve efficiency and transparency. The system uses fingerprint data to generate a unique number for each voter, providing confirmation and error messages. A remote server manages image processing and data transfer, while a central database, the Central Identities Data Repository, holds demographic and biometric information. Zonal databases support this system in reducing load. Voter authentication involves entering personal details, verifying age, and receiving a unique 4-digit number, with fingerprint enrollment and biometric verification ensuring valid voting. Challenges include issues in rural areas, power shortages, and inadequate network infrastructure, but the authors believe these can be overcome as education and urbanization increase (Abinaya & Gowthami, 2017).

DOI: 10.17148/IJARCCE.2024.13908

The authors gave ideas in the paper "Aadhar Based Election Voting System" in 2018. In this, the voter's fingerprints were scanned in the voting compartment, and this scanned information was compared to check voters' details. After verification, the voter is allowed to vote from the candidate list. The entire voting process was based on the Internet. With the help of this system, a voter is permitted to cast a vote from any city without a home constituency anywhere in India. According to the authors, this is secure and fast (Kasliwal, A.R. et al., 2018).

In "Iris Based E-Voting System" the author proposed a system that combines an Iris scanner, EVM, and Aadhar data to improve voting security. The 3M Congent dual Iris Scanner captures eye patterns for biometric identification. The system cross-references Iris scans with Aadhar data, verifies age and identity, and reduces false matches while eliminating the need for physical contact with shared equipment. This approach aims to ensure a secure and efficient voting process (Jayakumar, 2019).

b) Magnetic card-based voting machine

In the paper "Smart and Secured Voting System using Magnetic Stripe Voter ID Card and Cloud Storage: A Client-Server Paradigm" the authors proposed a system utilizing magnetic stripe voter ID cards. Information is stored on the card, and a magnetic card reader, along with a fingerprint scanner and EVM, is installed at polling booths. Voter authentication involves inserting the card into the reader, verifying data via a client-server model, and performing biometric checks. After successful verification, the EVM activates for voting, and votes are stored in cloud storage for the result declaration. Voters with mismatched information are denied access. The system requires magnetic stripe cards, readers, cloud storage, biometric sensors, and internet-connected EVMs (Budaragade & Biradar, 2008).

ii) BIOMETRIC-BASED VOTING MACHINES

a) Fingerprint-based voting machines

The authors proposed enhancing EVMs with fingerprint scanning to improve accuracy and verifiability under the title "A Novel Design of Electronic Voting System Using Fingerprint" in 2011 paper. They discussed two fingerprint recognition systems: automatic authentication and identification/verification. These systems involve capturing a physical fingerprint, processing it with image techniques, and comparing it with stored data. The process includes data acquisition, image pre-processing, enhancement, feature extraction, and matching. The enrollment process involves scanning and storing fingerprint data during registration, while live scans validate or invalidate voters. Only valid voters are permitted to vote (Kumar & Begum, 2011).

Another paper entitled "Design of Biometric Electronic Voting Machine" was proposed using biometric system for voter verification by the authors. The system assigns nine keys for nine candidates and supports up to 10,000 votes. Results are displayed after entering a password. The design includes power supply units, fingerprint scanners, controllers, and other components. Fingerprint templates are stored in a database for comparison with live scans during voting (Saxena et al., 2017).

b) Iris recognition-based voting machines

A voting system that uses retina scanning technology for secure identification was proposed in the paper "Voting System using Retina with Secure Socket Tunneling Protocol" by the authors. Instead of traditional EVMs, this system assigns each voter a unique ID number and scans their retina, which has a unique pattern that doesn't change over time. This two-step process enhances security and reduces the risk of fraud. Votes are securely transferred to the server using a tunneling protocol, protecting against hacking. After voting, the Chief Election Commissioner must pass additional checks, including entering a serial number and undergoing fingerprint scanning, before results are published online. This system combines advanced biometric technology and secure protocols to ensure a reliable voting process (Jayachitra et al., 2015). The authors proposed using Aadhar card details and iris recognition for voter verification in the paper entitled "Iris Based E-Voting System Using Aadhar Database". They highlight limitations of fingerprint systems, such as errors from dirty skin or age changes. Instead, the system uses an iris scanner to compare iris images with those in the Aadhar database. An E-Voting machine counts votes, and data are sent online to the server. An Arduino system manages this process, and a completion message is shown after voting (Saravanan, Pavithra, & Nandhini, 2017).

In "Design and Development of Biometric Enabled Advanced Voting System" the authors proposed using both iris recognition and fingerprint scanning to improve voting accuracy. The system involves registering voters, candidates, and officials online, verifying their IDs, and setting up machines with iris and fingerprint sensors. Only those with matching biometric data can vote. This method aims to ensure secure and accurate voting with rigorous verification processes (Jatain, 2020).

DOI: 10.17148/IJARCCE.2024.13908

c) Facial recognition-based voting machines

In the 2018 paper "Secured Electronic Voting System using Biometrics" the authors proposed a voting system using both fingerprint and facial recognition. A web camera captures facial images, which are compared with stored data using the Viola and Jones algorithms. Fingerprints are also matched with stored data. If the system identifies a mismatch, it sounds like a buzzer. Only authenticated voters can vote, and results are displayed after an authorized person verifies their fingerprint. The system is considered very secure (Karthik et al., 2018).

In the 2022 paper "Smart Online Voting System using OTP Authentication and Face Recognition" Sakshi Mehar proposed an online voting system using OTP and facial recognition for authentication. The system includes a four-stage algorithm for facial recognition, and votes are cast online. Voters receive an OTP on their mobile phones, and facial recognition is used for a second verification step. Voters must pass both checks to vote. The system is designed to be secure, cost-effective, and efficient, with results accessible online (Meher, 2022).

Rutuja B. Adrak and others introduced a model using facial recognition with the Local Binary Patterns Histogram algorithm in 2022 under the title "Smart Voting System Using Deep Learning and Computer Vision". Voters register with demographic details and a live image, which are stored in a database. The system uses convolution operations and the haar cascading classifier for image detection. Admins manage nominations and results, while voters are authenticated via facial recognition before casting their votes (Adrak & Bardekar, 2022).

The paper entitled "Online Voting System Using Fingerprint Sensor, Face Recognition and QR Code Scanner" proposed a system that combines facial recognition, fingerprint scanning, and QR codes for authentication. The system uses SHA 256 for fingerprint encryption, a face recognition library, and Google links for QR codes. Users must register and use one of these methods to gain access and cast a vote. The system prevents multiple votes from the same user and includes roles for super admin, admin, and user (Shubhangi et al., 2022).

iii) NETWORK/ INTERNET-BASED VOTING MACHINES

a) Cloud technology-based voting machines

In the paper "Online Voting System Using Cloud" the authors proposed a cloud-based voting system that integrates with the National Database and Registration Authority of India and the Election Commission of India. Voters log in to the system to view candidate lists and cast a single vote before the election deadline. Votes are validated, and results are shown graphically (Govindaraj et al., 2020).

The paper "Online Voting System Using Cloud Computing" presents a secure online voting platform where users can log in, choose candidates, and vote via a website. The system includes a secure login, a database for votes, a results panel, and a chatbot for assistance. It aims to improve and expand online voting for national elections in the future (Dandekar et al., 2022).

b) Blockchain technology-based voting machines

The blockchain-based voting system titled "Implementation of Secure Voting System using Blockchain" features two main components: the Administrator Module and the User or Voter Module. The Administrator Module allows authorized users to manage voter and candidate details, oversee voting, and address any vote tampering. The User or Voter Module enables voters to view candidate names and cast their votes. Security is maintained through ECC cryptography, where public keys are shared, and private keys are kept confidential, akin to passwords. Voting data is stored in tamper-proof blocks on a blockchain, starting with the Genesis Block and expanding with new blocks, each containing a username, hash value, and timestamp (Pawar, D. et al., 2020).

A paper presented at the "National Conference on Smart Systems and Technology" introduced a blockchain voting system using cryptography and timestamps. It covered different blockchain types—public, private, consortium, and hybrid—and used technologies like Node.js, Angular, and Hyperledger Sawtooth. The system features a two-phase interface: the uploader-client phase for storing voter and candidate data and the voter-client phase for casting votes. It prevents multiple votes by the same user. The paper discussed the interface's functionality and limitations (Aswathy, J.S. et al., 2021).

A paper in the International Journal of Scientific Research in Science and Technology described a blockchain-based e-voting system where administrators use Solidity to log in, and users verify their identity through Aadhar. The blockchain ensures vote authenticity through consensus mechanisms, making the process secure and transparent. Results are automatically declared and publicly accessible. The system includes an admin interface, smart contracts for election rules, and records all transactions on the blockchain (Pathak M. et al., 2021).

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The "MyVote—Blockchain-Based Online Voting System" paper introduces a global, decentralized e-voting system aimed at improving transparency and security. It includes user registration, face capture, Aadhar and OTP login verification, and secure voting. Future enhancements could add report generation and integrate the Aadhar Card API and fingerprint biometrics for stronger authentication. The system's features, including registration, face capture, login, and result display, contribute to a user-friendly experience (Ridhorkar S. et al., 2023).

c) IoT technology-based voting machines

In the 2018 paper "Aadhar-Based Electronic Voting System and Providing Authentication on Internet of Things" the authors proposed a voting system using Aadhar card details and IoT technology. Voters first scan their Aadhar card, and this information is sent to a microcontroller to access stored data. Next, a fingerprint scan verifies the details. If the biometric information does not match, the voter cannot cast a vote. The authors claimed this system was both secure and fast (Latha, V. et al., 2018).

V. Revathy published a paper titled "Implementation of Smart Election System using IoT" which also used fingerprint scanning for voter authentication, in 2022. This system stores a list of voters who have cast their votes in a centralized database. Voters are authenticated by scanning their fingerprints, and if their details do not match the database, they cannot vote. The system uses hardware like a fingerprint scanner, ESP32 microcontroller, LCD screen, and buzzer, with data stored on a server and accessed via IoT. If a voter tries to vote more than once, an alarm sounds, and the system displays a message that the vote has already been cast. If everything is in order, the voter can cast their vote, and the server updates the database and displays the voting status (Revathy, V. et al., 2022).

d) Web technology-based voting machines

The authors proposed a web-based voting system using token authentication, a chatbot for natural language queries, and a captcha system in the paper "Token Authentication based Election System with AI Bot". The AI bot helps voters with their questions, while the token confirms authentication when logging in. If complaints are registered, the Election Commission (ECI) issues notifications. If the same complaint is repeated three times, the polling station is blocked. The system uses the salt algorithm for security. The ECI module updates candidate and voter information and manages various election activities. In contrast, the admin module handles pre-, post, and during-election tasks. Voters log in with a token; if valid, they can vote, use AI bots, and raise queries. The system is designed to be secure and user-friendly (Brintha et al. et al., 2019).

The paper "Electronic Voting System Using Aadhar" proposed a voting system using Aadhar card details on a webpage. The system includes four modules: Voter Registration, Authentication, Vote Recording and Casting, and Vote Counting. Voter registration collects demographic information and fingerprint scans. After authentication, voters log in using credentials, and privacy is maintained during online voting. Results are displayed after voting (Gowsalya C. et al., 2020). The 2021 paper "E-Voting: The Next Generation Election" discusses an internet-based voting system. Voters log in using OTP authentication on a web portal. The system stores databases online with comprehensive voter and candidate information. It is described as secure, interactive, and faster compared to existing systems (Chaudhari N. et al., 2021).

iv) OTHER TECHNOLOGY-BASED VOTING MACHINES

This section discusses on those electronic voting machines which have not been discussed in the above sections. Discussion is based on mostly patent literature, a few of them are from non-patent literature also.

Prakasham Uma Pathy filed a patent application (No. 377/CHE/2004) titled "An Apparatus and a Method of Electronic Voting with Verification Capability" for an enhanced electronic voting machine. This machine features three user levels: CEO, PO, and voters. The CEO configures the machine, checks for any residual data, verifies the battery and printer, and sets up other settings. The PO supervises polling and verifies voter credentials. The voting process involves a touchscreen and a Secret Voting Code (SVC) to ensure vote secrecy. The machine records votes and prints a unique number for each vote, providing a legal substitute for paper ballots. It operates in Configuration, Voting, Collation, and Display Modes (Prakasham Uma Pathy, 2005).

Margaret Dumebi Okpor proposed a system in 2017 titled "An Enhanced Electronic Voting System with Hybrid Authentication Technique" to address multiple registrations, underage voters, and overvoting. The system uses a Rapid Application Development (RAD) approach with three modules: Admin, Agent, and Voter. The Admin module manages election setup, staff authentication, and results, while the Voter module handles voting. All credentials require biometric authentication and unique IDs. Technologies used include VB.net, MySQL, Java, PHP, and cryptography, aimed at secure, reliable elections (Margaret Dumebi Okpor, 2017).

DOI: 10.17148/IJARCCE.2024.13908

Aashutosh Kumar's patent application (No. 201741017395) describes an EVM with photo and video cameras to enhance vote verification. The cameras capture images of the voting buttons and voters' fingers, maintaining voter privacy. The system compares vote counts with camera images and uses video recordings to resolve discrepancies. Images are stored on a 'Write Once' memory card for secure, tamper-proof results (Aashutosh Kumar, 2017).

In 2018, M/S Bharat Electronics Limited filed a patent (No. 201841002146) for an Enhanced Electronic Voting Machine (eEVM). The eEVM includes Ballot Units (BUs) with voting keys, Control Units (CUs) for authentication and vote storage, and a First Level Check Unit (FLCU) for health checks. It features a Printer and Auxiliary Display Unit (PADU) for reports and diagnostics, a Voter Verification Unit (VVU), and uses public key cryptography to ensure security. The system handles vote counting and displays results (M/S Bharat Electronics Limited, 2018).

The authors proposed an IoT-based biometric fingerprint voting system where voters scan their fingerprints instead of using ID documents. The system checks the fingerprint against a database and, if matched, allows voting via a touchscreen interface. It employs Arduino modules for processing and includes three modes: enrollment, voting, and result display (Pal, S. et al., 2019).

Satyamurthy Konaur Ramachandra's patent (No. 201941050994) introduces a voting method with a supervisor unit and voting unit. It includes a mock election option, prints party symbols for votes, and displays results. The system uses microprocessors to manage and verify votes, with a printer providing physical records (Satyamurthy Konaur Ramachandra, 2019).

Ajay Kumar Garg's patent application (No. 202211042661) describes a Secured Voting System with two-level authentication. It involves scanning an identity card, biometric verification, and token allocation. The system uses blockchain for secure vote recording, and a microcontroller manages voter interactions and results. It includes GPS for location verification and a battery for power (Ajay Kumar Garg, 2022).

The authors, "Smart Voting System using Deep Learning Techniques" use facial recognition and machine learning for online voting. It employs Haar Cascades with Adaboost for feature extraction and CNN algorithms for drone detection. Users register with facial images, and the system updates results automatically. It ensures security through various testing phases (Nisha P. Pooja & Anuja T., 2022).

The "Autonomous Remote Electronic Voting System using Blockchain" aims for secure remote voting with anonymity. It involves biometric authentication, blockchain for vote encryption, and phases for authentication, polling, and result verification. It features distributed key generation and end-to-end verifiability for a trustworthy voting process (Neelakandan, S., Paulraj, D., & Sethukarasi, T., 2023).

The paper under the title "Design & Development of Online Voting System" provides a digital voting solution for Indian citizens, eliminating physical polling booths. It ensures voter security, prevents multiple voting attempts, and balances ballot security with accessibility, offering an efficient digital electoral process (Banalamath, A. et al., 2023).

A patent application under the title "REMOTE VOTING MACHINE (RVM) SYSTEM" was published in 2023. The invented machines facilitate remote voters who temporarily resides away from their home constituencies due to their work, study, or business purpose. The RVM system addresses this issue by facilitating remote voters to cast their votes from their present place of residence without visiting their home constituencies physically.

The RVM system includes several key components: a Multiconstituency Control Unit (MCU); a Multiconstituency Ballot Unit (MBU); a Public Display Unit (PDU); a Cast Vote Verification Unit (CVVU); a QR Code Scanner; a special Printer, and special connecting cables. This invention represents an advancement over an existing Electronic Voting Machine (EVM). The MCU functions are- issuing ballots, counting votes, and displaying results. The MBU displays the digital ballot according to the constituency of the voter and allows the voter to cast a vote.

The PDU provides a visual and auditory display of voter information and election results. Voters are allowed to verify their cast vote through a glass window of CVVU. The QR Code Scanner reads voter identification slips to confirm voter details. The special printer to take printouts of the polled votes on the day of counting. The connecting cables are specialized for linking the components of RVM. Authors ensured that a single RVM is capable of conducting elections for multiple constituencies is safe and secure (Rohil H., et al., 2023).

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024

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Table 2: Summary of Voting Machine Available in Literature

Sr. No.	Name of Researcher	Year	Title of publication	Type of Literature	Technology Used
1	Prakasham Uma Pathy	2005	An Apparatus and a Method of Electronic Voting with Verification Capability	Patent Literature	Stand Alone Machine
2	Budaragade, A. P., & Biradar, V. R.	2008	Smart and Secured Voting System using Magnetic Stripe Voter ID Card and Cloud Storage: A Client-Server Paradigm	Non-Patent Literature	Cloud-Based
3	Kumar, D. A., & Begum, T. U. S.	2011	A novel design of Electronic Voting System Using Fingerprint	Non-Patent Literature	Biometric Based
4	Yadav, V. K., Batham, S., Jain, M., & Sharma, S.	2014	An Approach to Electronic Voting Using UIDAI	Non-Patent Literature	Aadhar Card Data
5	Jayachitra, R., Kalaiyarasi, K., & Kavitha, R.	2015	Voting system using Retina with Secure Socket Tunneling Protocol	Non-Patent Literature	Internet, Biometric Based
6	Bhuvanapriya. R, Rozil banu.S, Sivapriya.P, & Kalaiselvi.V.K.G.	2017	Smart Voting	Non-Patent Literature	Aadhar Card Data, Biometric Based
7	Abinaya, M., & Gowthami, K.	2017	Online Voting System Powered By Aadhar Authentication	Non-Patent Literature	Aadhar Card Data, Biometric, Web Based
8	Saxena, P., Prakash, S., & Pandey, P.	2017	Design of Biometric Electronic Voting Machine	Non-Patent Literature	Biometric Based
9	Saravanan, N., Pavithra, K., & Nandhini, C.	2017	Iris Based E-Voting System Using Aadhar Database	Non-Patent Literature	Aadhar Data and Biometric Based
10	Margaret Dumebi Okpor	2017	An Enhanced Electronic Voting System (EnEVoS) with Hybrid Authentication Technique	Non-Patent Literature	Web Based, Biometric Based
11	Ashutosh Kumar	2017	Electronic Voting Machine (EVM) With Ballot Paper Like Functionality Too, Without Using Any Paper	Patent Literature	Video recording of BU
12	Kasliwal, A. R., Gadekar, J. S., Lavadkar, M. A., Thorat, P. K., & Deshmukh, P.	2018	Aadhar Based Election Voting System	Non-Patent Literature	Aadhar DataBased
13	Karthik, G. M., Vineesha, T., Veena, G., & Sujay, S.N.	2018	Secured Electronic Voting System using biometrics	Non-Patent Literature	Biometric Based
14	Latha, V., Adikesavan V, Thirumalaic, S., Vignesh, T., & Vishal, P.	2018	Aadhar based Electronic Voting System and Providing Authentication on Internet of Things	Non-Patent Literature	IoT, Aadhar Based
15	M/S Bharat Electronics Limited	2018	Enhanced Electronic Voting Machine (eEVM)	Patent Literature	Stand Alone
16	Jayakumar, R.	2019	Iris Based E-Voting System	Non-Patent Literature	Biometric Based
17	Brintha Asha, S., Ganaka Durga, P., Sivaranjani, R., & Steffi E F Shaniya.	2019	Token Authentication based Election System with AI Bot	Non-Patent Literature	AI-Based
18	Satyamurthy Konaur Ramachandra	2019	Voting System	Patent Literature	Stand Alone machine
19	Pal, S., S.Balamurugan, Banerjee, S., Touminur, R., Mandal, P., Roy, M., & Bose, A.	2019	IoT-Based Biometric Fingerprint Voting System	Patent Literature	IoT, Biometric Based
20	Jatain, A., Arora, Y., Prasad, J., Yadav, S., & Konark, S.	2020	Design and Development of Biometric Enabled Advanced Voting System	Non-Patent Literature	Biometric Based

DOI: 10.17148/IJARCCE.2024.13908

Sr. No.	Name of Researcher	Year	Title of publication	Type of Literature	Technology Used
21	Govindaraj, R., Kumaresan P, & Sree Harshitha, K.	2020	Online Voting System Using Cloud	Non-Patent Literature	Cloud-based
22	Pawar, D., Sarode, P., Santpure, S., Thore, P., & Nimbalkar, P.	2020	Implementation of Secure Voting System using blockchain	Non-Patent Literature	Block Chain
23	Gowsalya, C., Manimozhi, S., Rragavi, R., & Visali, K.	2020	Electronic Voting System Using Aadhar	Non-Patent Literature	Aadhar Data Based
24	Aswathy, J.S., Bertila, M., Maria, M., Joseph, S.A.S., & Nisha J.R.	2021	Blockchain Voting System	Non-Patent Literature	Block Chain Based
25	Pathak, M., Suradkar, A., Kadam, A., Ghodeswar, A., & Parde, P.	2021	Blockchain Based E-Voting System	Non-Patent Literature	Block Chain Based
26	Chaudhari, N., Shinde, V., Gajare, N., Suryawanshi, P., & Bhosale, S.	2021	E-Voting: The Next Generation Election	Non-Patent Literature	Internet Based
27	Rutuja B. Ardak, & Dr. Aashish S. Bardekar	2022	Smart Voting System using deep learning and Computer Vision	Non-Patent Literature	Deep Learning
28	Meher, S., Muley, P., Pawar, S., & Solanke, A.	2022	Smart Online Voting System using OTP Authentication and Face Recognition	Non-Patent Literature	Biometric Based
29	Shubhangi, D. Dhane, & Rathod, S. B.	2022	Online Voting System Using Fingerprint Sensor, Face Recognition and QR Code Scanner	Non-Patent Literature	Biometric Based
30	Dandekar, D. B., Umratkar, G., Manwar, P., Sute, S., Ansari, Z., Khan, H., Ansari, B., & Joshi, B.	2022	Online Voting System Using Cloud Computing	Non-Patent Literature	Cloud Computing
31	Revathy, V., Rubika, V., Sadhana, M., & Arthi, K.	2022	Implementation of Smart Election System using IoT	Non-Patent Literature	IoT Based
32	Nisha P. Pooja, & Anuja T.	2022	Smart Voting System Using Deep Learning Techniques	Non-Patent Literature	Biometric Based Machine Learning, Online Voting
33	Ajay Kumar Garg	2022	Secured Voting System	Patent Literature	Block Chain, Bi Biometric Based
34	Ridhorkar, S., Wanjari, M., Ansari, S., & Sonwane, P.	2023	MyVote-Blockchain Based Online Voting System	Non-Patent Literature	Block Chain
35	Neelakandan, S., Paulraj, D., & Sethukarasi, T.	2023	Autonomous Remote Electronic Voting System using blockchain	Patent Literature	Blockchain, Biometric Based
36	Banalamath, A. V, Basavaraj, A. K., Chetan, J. B., & Kallesha, H. U.	2023	A Design & Development of Online Voting System	Patent Literature	Internet Based
37	Rohil, H., Rohil, M., Kumar, N., Singh, P., Jaglan, V., Dalal, S., Kumar, S., & Sunesh.	2023	REMOTE VOTING MACHINE (RVM) SYSTEM	Patent Literature	Stand Alone

IV. CONCLUSION

In conclusion, this paper provides an in-depth examination of both existing and proposed voting machines by exploring their technological advancements and categorizing them based on their development and usage. This paper provides a thorough review of voting machines, categorizing them into two main groups: those currently in use and those proposed in the literature. The discussion covered a variety of existing voting machines, such as punch cards, electronic cards, OMR, OCR, and DRE systems, highlighting their widespread application in the first category followed by a table showing voting machines used in different countries. In the Second category, proposed machines are categorized into card-based, biometric-based, network/internet-based, and other technology-based systems, including those utilizing Aadhar cards,

DOI: 10.17148/IJARCCE.2024.13908

biometric data, cloud computing, and blockchain technology. The summary of these categorized voting machines is also shown year-wise in a table after describing the authors' work. This paper gives a comprehensive overview of all kinds of electronic voting machines.

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