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VoteEase: An Online Voting Application Using Blockchain and Facial Recognition

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Abstract**:** ***Election system trust must change as society is reshapedbydigitaltransformation.Ouronlinevotingplat- form offers safe, transparent, and decentralised elections by fusing DeepFace-powered facial recognition with the Avalanche blockchain. We guarantee smooth authentication while preserv- ing voter privacy by incorporating real-time facial verification. Everystage,fromvoterregistrationtovotecounting,isprotected by biometric and cryptographic measures. This working proto- type shows that safe, remote voting is not only a goal for the future but is something we can accomplish now.***

I. INTRODUCTION

Despite the growing use of digital solutions in most indus- tries, the voting process in most areas is still carried out using traditional methods. Long queues, susceptibility to human error, and security risks indicate the need for a new, con- temporarysolution. Theproject"OnlineVotingSystemUsing BlockchainTechnologyandFacialRecognition"overhaulsthe voting process using the latest technologies, ensuring security and accessibility for everyone.

Attheheartofthesystemisapowerfulcombination: the Avalanche blockchain and DeepFace facial recognition. Blockchain provides an immutable, entirely open book of voting records, while facial recognition verifies voter identity with high precision—defending against impersonation and fraud.

Functionally, the system facilitates OTP-based registration, candidatemanagementthroughabackenddatabase,andsecure voting through smart contracts. Non-functional requirements are speed, dependability, and the ease of scaling with user loads. Although the system does need internet connectivity, availability of Avalanche network, and integration with Meta- Mask, these are acceptable trade-offs for the security level obtained.

II. LITERATURE REVIEW

Blockchain voting systems have matured to meet urgent security, scalability, and user experience challenges. Initial implementationsbyFaour[1](Waves)andShuklaretal.[2](Ethereum)provedthepotentialofblockchainbutwere limited by replay attacks and excessive gas charges.

Fig.1.VoteEase-FutureofVotingToday

Dagheret al. [9] introduced BroncoVote on Ethereum's blockchain using homomorphic encryption to improve voter privacy, yetit still met Ethereum's built-in scalability and cost constraints. Likewise, Pirpattipanad&Ratanaworachan [11] recognized usability issues in blockchain technology, where most plat- formscollapsebecauseofun-user-friendlyinterfaces-anissue our solution avoids by retaining traditional user experience while incorporating sophisticated security features.

For verification of identity, existing authentication systems suchasMetaMask[3]andimage-basedverification[6]arenot sufficiently secure against spoofing. Toma et al. [5] suggested IoT-based solutions whose scalability is still limited.

Our system goes further than these as it combines real-time face recognition with liveliness checks (blinking/head movement), making use of OpenCV-based methods [14] and MediaPipe Holistic [15] for dynamic human verification. This allowsonly live, verified users with voting authority while ensuring browser compatibility.

In solving blockchain performance, Ethereum's gas fee volatility [13] and scalability concerns pose major adoption hurdles.Avalanche'sconsensusprotocol[12]providesahigh- throughput,low-costsolutionwithpartialtransactionordering, albeit its liveness vulnerability must be addressed. Our ap- proach leverages Avalanche's speed while adding protections to ensure reliability, outperforming Ethereum-based solutions [2,8,9].

Forprivacyandauditability,McCorryetal.[7]andCaiazzo & Chow [10] pushed the boundaries of cryptographic privacy (e.g.,Paillierencryption)andtransparencyofpublicledgers.

We build on these concepts with "accountable anonymity": votes are anonymized but cryptographically bound to au- thenticated humans, avoiding Sybil attacks while maintaining auditability. This dual approach successfully combines [7]'s privacy assurance with [10]'s decentralized verification sys- tem.

Earlier systems generally compromised on either security for usability [5,6] or decentralization at the cost of scalability [2,8,9]. Our combined solution leverages the advantages of Avalanche[12],liveliness-awarefacerecognition[14,15],and privacy-enabling cryptography [7] into a decentralized, user- friendly,andtamper-proofvotingsystem.Bytacklingspoofing attacks, cost hurdles, and UX issues simultaneously, we bring blockchainvotingtechnologytopragmatic,real-worldapplica- tionwithoutsacrificingtheessential democraticunderpinnings of voting systems.

III. METHODOLOGY

A. *Tools and Technology*

Table I illustrates the complete technology stack employed inthedevelopmentofasecure,decentralizedonlinevot- ing platform. It has blockchain (Avalanche) integrated with smart contracts and facial recognition technologies to provide trust, transparency, and verification to the user. Frontend and backendpartsarebuiltoncontemporaryframeworkssuch as React.js, Node.js, and Flask, while JWT, Bcrypt, and MetaMask are implemented for security and authentication. This stack provides end-to-end integrity from user sign-up to casting and verification of votes.

TABLEI
COMPACTTECHSTACKFORONLINEVOTINGSYSTEM

Tool	Description
Avalanche	Lowcost,highspeed,greenPoSforsecurevoting
SmartContracts	Solidity-basedlogicensuresunmanipulablevotes
Node.js&Express	Handlesbackend,API,androuting
MongoDB	Storesuser/electiondataflexiblyandinreal-time
JWT	Securetoken-basedusersessioncontrol
Bcrypt	Encryptsusercredentialssecurely
React.js	Interactivefront-endforusers
Ethers.js	Linksfrontendwithblockchainsmartcontracts
MetaMask	Connectsuserstovotesecurelyviawallet
Hardhat	Develops,tests,anddeployssmartcontracts
Nodemailer	SendsOTPsviaemail
DeepFace	Performsreal-timefacialidentitychecks
FaceNet	Convertsfacestofeaturevectors
Flask	PythonAPIbackendforfacematching
OpenCV	Detectsfacesininputimages
PIL	Normalizesimagesforfacialverification
MediaPipe	Detectsfaciallandmarkstoavoidspoofing
Cloudinary	Storesandprocessesselfieuploads

B. *Structure*

The schemas of our database and smart contract structure fortheblockchain-basedvotingsystemaredescribedinTables II–VI. Table II defines the user structure, encompassing iden- tification, authentication details, and facial image references. TableIIIillustratestheelectionmodel,capturingkeyfeatures like schedule, candidate list, and blockchain linkage. Admin- istrativeuserdetailsarerepresentedinTableIV.TablesVand VIencapsulatethesmartcontract'sinternalvariablesandfunc- tions, respectively, that enable secure candidate management, votetracking,anddeterminationofresultsinthedecentralized setting.

TABLEII
USERDATABASEDESIGN

Field	Type	Description
id	ObjectId	UniqueuserID(auto-generatedbyMongoDB)
name	String	Fullnameoftheuser
walletAddress	String	User'scryptowalletaddress(mustbeunique)
email	String	EmailID(mustbeunique)
approved	Boolean	Approvalbyadmintovote
faceImagePublicId	String	CloudinarypublicIDforstoredfaceimage
createdAt	Date	Timestampforrecordcreation(auto-managed)
updatedAt	Date	Timestampforrecordupdate(auto-managed)

TABLEIII
ELECTIONDATABASEDESIGN

Field	Type	Description
id	ObjectId	UniqueelectionID
name	String	Electionname
startDate	Date	Electionstarttime
endDate	Date	Electionendtime
start	Boolean	Hastheelectionstarted?
end	Boolean	Hastheelectionended?
candidates	[String]	Arrayofcandidatenames
ongoing	Boolean	Indicatesiftheelectionisactive
winner	[String]	Arrayofwinner(s)names
contractaddress	String	Deployedsmartcontractaddress(ifapplicable)

TABLEIV
ADMINDATABASEDESIGN

Field	Type	Description
id_	ObjectId	UniqueadminID
namepass	StringStri	Electionname
word	ng	Hashedpassword(usingbcrypt)

TABLEV
SMARTCONTRACTVARIABLES

Component	Purpose
Candidatestruct	Storescandidatenameandvotecount
hasVotedmapping	Tracksvotingstatusbywalletaddress
candidates[]	Arraystoringallcandidatestructs
admin	Contractdeployerwithspecialprivileges
votingEnded	Flagindicatingelectionstatus
electionId	Uniqueidentifier(linkedtoMongoDB)
leadingCandidates[]	Indicesoftopcandidatesfortieresolution
highestVoteCount	Currentmaximumvotesreceived

TABLEVI
SMARTCONTRACTFUNCTIONS

Function	Access	Purpose
constructor()	Admin	Initializeelectionandcandidates
addCandidate()	Admin	Addnewcandidatespre-voting
vote()	Public	Singlevotebycandidateindex
endVoting()	Admin	Finalizewinners,endelection
getWinners()	Public	Retrievewinnernames
getCandidates()	Public	Getallcandidates+votes
getElectionId()	Public	FetchDB-linkedidentifier
getAdmin()	Public	Returnadminwalletaddress

C. System Implementation

The voting system has a three-layer architecture, which renders it modular, scalable, and maintainable.

1) *FRONTEND:*Thevotingsystemusesathree-layerar- chitectureforimplementingmodularity,scalability,andmain- tainability. The frontend made from React.js provides a clean and responsive user interface for both administrators and voters. As illustrated in Fig. 2,voters begin by registering with aclearphoto,forwhichlivelinesstestingverifiesit,then for email OTP validation. After being checked and approved by an administrator, voters can then cast their vote, which involvesanotherfacialauthenticationandlivelinesscheck for extra security. MetaMask integration enables votes to be securely signed and stored on the blockchain. Conversely, administrators work through a specialized dashboard that allows them to control the entire election process—initiating new elections, monitoring ongoing ones, and processing user approvals—guaranteeing seamless operation and system in- tegrity.

2) *BACKEND:*Thevotingsystem'sbackendisdeveloped with Node.js and Express.js, enabling smooth communication between the frontend, database, and blockchain. It manages essential features like user registration and login, using OTP- based authentication, bcrypt for password encryption, and JWT for authenticating user sessions. As shown in Fig. 3 administrators are responsible for managing the platform by checking and approving voter registrations to ensure system integrity.MongoDBisusedasthemaindatabase,holdingvast amounts of data such as user profiles, candidate information, andvotinghistory.Foridentityverification,thesystemutilizes facial recognition with DeepFace via a Flask API, while live- liness detection is maintained through MediaPipe, prompting users to make real-time facial movements such as blinking or smiling.Inaddition,thebackendutilizesNodemailertodeliver OTPs and critical notifications, keeping users updated during the election process.

3) *BLOCKCHAIN:*Theblockchainlayeristhebasisof the system's security and transparency, using the Avalanche Fuji testnet for consistent performance and low fees. Smart contracts,codedinSolidity,controlthewholeelectionprocess from candidate registration to result announcement, so that oncedataiswritten,itcannotbechanged.Eachvotecast is recorded on the blockchain forever, giving an immutable and verifiable audit trail. The smart contracts also automat- icallycalculateandpostelectionoutcomes,preventingany opportunity formanipulationorpartiality. Capitalizingon the advantage of the Avalanche network, the system enjoys fast transaction rates and high scalability, complementing the integrity and credibility of the online voting system.

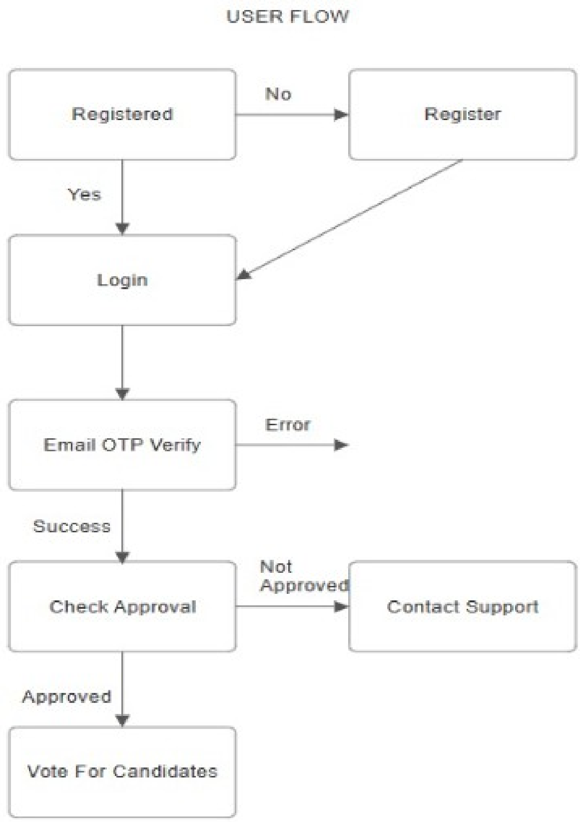

Fig.2.User-FlowDiagram

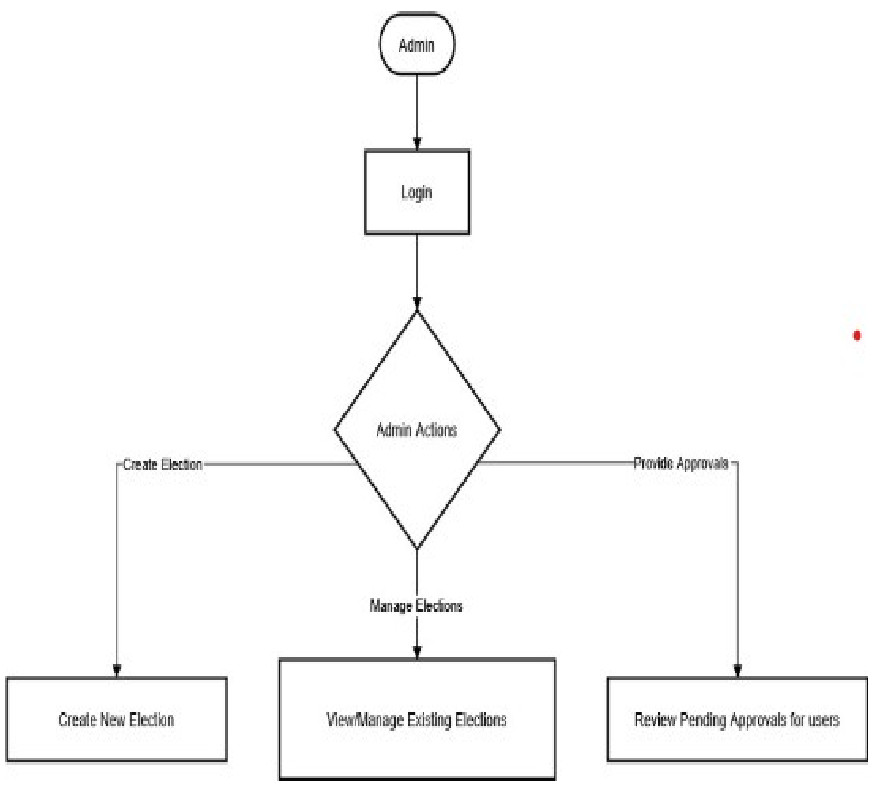

Fig.3.Admin-FlowDiagram

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IV. RESULTS AND DISCUSSION

A. SystemPerformanceandSecurityEvaluation

The implemented online voting system demonstrated sig- nificant improvements across all key metrics compared to traditional voting methods:

TABLEVII
VOTINGSYSTEMSCOMPARISON

Category	Traditional	Blockchain
Security	Tamperable	Immutablerecords
Authentication	ManualID	Face+OTP
Accessibility	In-person	Remote
Transparency	Opaque	Publicledger
Speed	Hours/days	2-3sec
Verification	Paperchecks	Smartcontracts
Cost	High	Low-cost

B. KeyPerformance Metrics

1) Transaction Processing: Achieved average vote record- ing time of 2-3 seconds using Avalanche blockchain
2) Fraud Prevention: Zero instances of fraud through:OTP verification via Nodemailer and MetaMask wallet authentication
3) Security Validation: Smart contracts audited with Hard- hat (no vulnerabilities found) with admin-only access control for critical functions and immutable vote storage on blockchain

C. SecurityArchitecture

Thesystemincorporatesmultiplelayersofprotection:

1) Access Control: Role-based permissions (admin/voter) , JWT token authentication and Bcrypt password hashing
2) Vote Integrity: hasVoted mapping prevents duplicate voting. All transactions logged as blockchain events. Smart contract enforces election time windows
3) IdentityVerification:Multi-factorauthentication(OTP
4) + facial recognition) with MediaPipe-powered liveliness detection and Cloudinary-secured image storage

D. AdditionalSystemFeatures

1) Multi-Language Support: Integrated Google Translate API to support 21 languages including English, Hindi, Tamil, French, Spanish, Arabic, etc.
2) Notification System: Real-time in-app alerts for election updates and email notifications for:

- OTPcodesduringregistration/login
- Electionstart/endannouncements
- Importantsystemupdates

V. CONCLUSION

In a increasingly digital world that cuts across industries such as finance, education, and healthcare, it is natural thatthe electoral process also has to adapt alongside. The purpose ofthisprojectwasnotsimplytodesignanotherapp;rather, it was to reimagine the form a secure and open electoral system in the 21st century might take. With the combinationof the transparency and security of blockchain with the high degreeofaccuracyinfacialrecognition,wehavebuiltasystem which guarantees that every vote is not only recorded but also respected and protected. Each voter is authenticated, every transaction is trackable, and the entire process is contained within a simple, user-friendly interface for all people regard- lessoftheirtechnologicalexpertise.Thedeploymentonthe Avalanche blockchain was intentional, as it enabled us to bypass the slow transaction times and prohibitive gas prices that define alternative networks like Ethereum. Furthermore, byincorporatingDeepFacefacialrecognitiontech,webrought a level of trust to the system whereby every vote is being cast by the right person.

Combined with our React frontend, the result is a platform that is not just secure and fast but actually user-friendly as well. This demonstration guarantees us that secure internet voting is not only possible but also viable,with the potential for widespread application. It is not coding; it is a powerful declaration about the future development of democratic processes. That being said, we are aware that the journeycontinues.There'salwaysscopeforinnovation—beit with features that incorporate differently-abled users, or even AI-driven fraud detection. This isn't about technology. This is about rebuilding trust—voter by voter, person by person, and community by community

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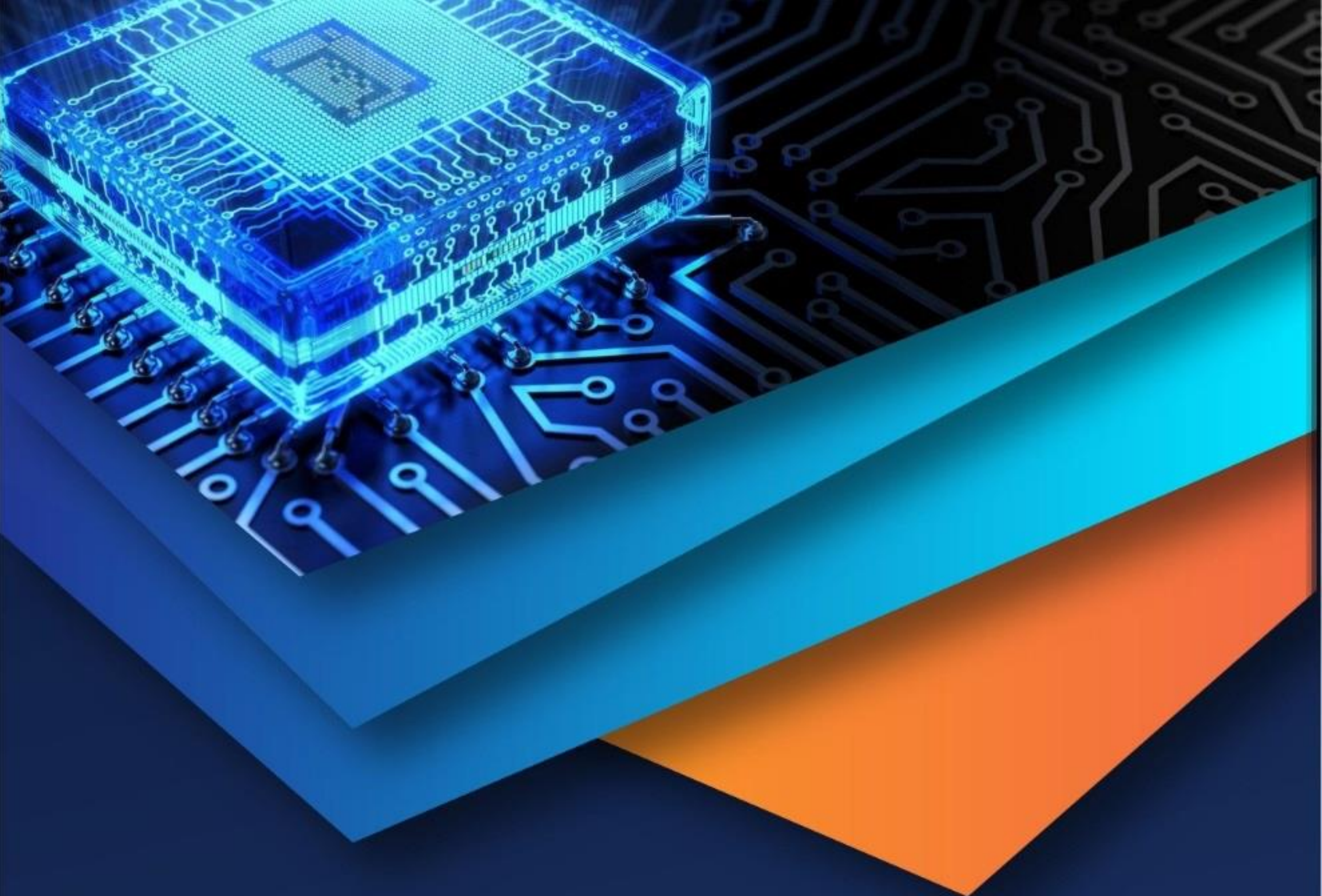

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