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A NOVEL HYBRID BIOMETRIC ELECTRONIC VOTING SYSTEM: INTEGRATING FINGER PRINT AND FACE RECOGNITION

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ABSTRACT

A novel hybrid design based electronic voting system is proposed, implemented and analyzed. The proposed system uses two voter verification techniques to give better results in comparison to single identification based systems. Finger print and facial recognition based methods are used for voter identification. Cross verification of a voter during an election process provides better accuracy than single parameter identification method. The facial recognition system uses Viola-Jones algorithm along with rectangular Haar feature selection method for detection and extraction of features to develop a biometric template and for feature extraction during the voting process. Cascaded machine learning based classifiers are used for comparing the features for identity verification using GPCA (Generalized Principle Component Analysis) and K-NN (K-Nearest Neighbor). It is accomplished through comparing the Eigen-vectors of the extracted features with the biometric template pre-stored in the election regulatory body database. The results of the proposed system show that the proposed cascaded design based system performs better than the systems using other classifiers or separate schemes i.e. facial or finger print based schemes. The proposed system will be highly useful for real time applications due to the reason that it has 91% accuracy under nominal light in terms of facial recognition.

INTRODUCTION

Electoral Systems empower the citizens of a country to elect parliament members of their choice. Paper based electoral system is a classical method to accomplish the said task. In this method, printed votes are submitted to various election booths of country at least one day before the election. After the election timings, sealed boxes containing votes are opened in front of all the legitimate members of booth and counted. The information of counted votes is submitted to a centralized station along with bags of paper votes. The central station compiles and publishes the names of winners and losers through television and radio stations. This method is useful only if the whole process is completed in a transparent way. However, there are some drawbacks to this system. These include higher expenses, longer time to complete the voting process, fraudulent practices by the authorities administering elections as well as malpractices by the voters [1]. These challenges result in manipulated election results Electronic Voting Systems provide efficient and reliable technique to empower citizens of a country or members of an organization to select a person of their choice. These systems can be classified into supervised, hybrid and remote voting styles. Supervised voting also known as offline voting is typically administered by electoral organizations. In this scheme, voting machines are located at polling machines. However, these machines are not

connected with a centralized system for cross-verification or any other purpose. Hybrid voting schemes are supervised by election organizing members, however, the machines are connected with internet, Remote voting refers to the schemes which are not administered by any supervising staff and the machines are connected with internet [2]. Benefits of using Biometrics in a voting system is to accurately recognize the voter which enables the election administrators to reduce the error rates by reducing fraudulent and bogus votes. Besides, it also results in cost efficiency, improving physical safety and increasing convenience to the users [3]. In this regard, various authors have developed the electronic voting systems. A smart card based voting system is developed by[4]. This smart card system has temporary and permanent storage facilities. To address fraudulent practices, this card also contains biometric information of the end user which can be authenticated by the system. Sehr [5] present a computerized voting system to address issues including low attendance of voters, higher administration and operation costs, longer time of tabulation, and inconvenience for voters, rigid voting guidelines, and inadequate security protection. Tagawa[6], present an innovative electronic voting system. The proposed system encodes voting information. This system consists of voting unit, polling administration unit, voter list administration unit and ballot or counting unit. After the vote is caste, the information is sent to polling administration unit along with the smart card number in encrypted manner. During the comparison if the information is found to be doubtful the vote will be rejected. Otherwise it can be preceded to the ballot counting unit. It is an effective system with proper data encryption and secrecy but it lacks one feature i.e. multiple votes by a single user. Evertz [7] presents a system using WAN (Wide Area Network) which is connected to a server at the election office containing the database of all the voters. First the voter has to verify its identity by facial recognition, in which features are extracted from the face of the voter and compared with pre-stored features in a database. Upon matching of the identity, a window will pop up on the screen of the computer where the voter can cast its vote. But the facial recognition system used and employed is quite in-effective having a success percentage of only 58% and a response time of 15 seconds. Besides, it lacks any data encryption or security for the secrecy of the ballot. Thus rendering it in-effective for use in real-time. To improve the confidentiality and privacy of the electronic voting systems, most of the systems use Mixnet or homomorphic encryption techniques [8]. Additionally, authors also claim that the homomorphic encryption is more appropriate for the situation with several election candidates as well as elections with neutral votes. The electronic voting system is implemented extensively in developed countries such as USA. Awad and Leiss [9], present a comprehensive study of conventional and electronic voting systems in USA along with their disadvantages. Alomari and Irani [10], present e-voting for a developing country, hence they concluded that the factors that Influence the adoption of e-voting includes trust in internet, trust in government, attitudes, website design, and compatibility including many others. Pesado et. al. [11], have presented the challenges and solutions of electronic voting system preferably for Argentina. Additionally, they have presented the characteristics of three different voting types, these include on site electronic voting system, partially onsite and remote voting system. Furthermore, policy considerations are also provided for the implementation of the proposed system. Jacobs and Oostdijk [12], present a system that uses bar coded identifiers which are assigned either randomly or pseudo randomly in the form of combination of numbers and alphabets. These encrypted codes provide security from any illegal intervention. Using different identifiers makes this system secure in comparison to others. The voter will then have to

scan the bar-code and then the system will decode and compare the code assigned with that of the database. Upon a perfect match the voter will be allowed to vote. Awan et. al. [13], implement a fingerprint based electronic voting system using Raspberry Pi board. Vidyasree et. al. [14], fuse the fingerprint and facial data to improve the identification of a voter through multimodal system. The results show a reasonable amount of improvement in comparison to unimodal system. Das et. al. [15], store biometric information of the user i.e. fingerprints on RF ID tags for designing an improved electronic voting machine. The proposed system also integrates the GSM module to disseminate information from the local station to other stations. We develop and present an electronic voting system to eradicate fraudulent practices during public elections by involving double user identification checks i.e. facial recognition and finger print based identification methods. Facial recognition is accomplished through a feature-extraction based machine learning algorithm, while finger print based identification is achieved through pattern recognition method. The facial recognition is accomplished through cascading of Global Principal Component Analysis and K nearest Neighbor algorithms. The proposed method will provide better accuracy in comparison to a single identification method.

Literature survey

Bhuiyan, M.S., Rehman, M.M., and Hossain, M.R. "Electronic Voting System", B.Sc. Thesis, Department of Computer Science & Engineering, , BRAC University, Dhaka, Bangladesh, January, 2007.

Systems-on-Chip's (SoC) design complexity demands a high-performance linear regulator architecture to maintain a stable operation for the efficient power management of today's devices. Over the decades, the low-dropout (LDO) voltage regulator design has gained attention due to its design scalability with better performance in various application domains. Industry professionals as well as academia have put forward their innovations such as event-driven explicit time-coding, exponential-ratio array, switched RC bandgap reference circuit, etc., to make a trade-off between several performance parameters such as die area, ripple rejection, supply voltage range, and current efficiency. However, current LDO architectures in micro and nanometer complementary metal– oxide–semiconductor (CMOS) technology face some challenges, such as short channel effects, gate leakage, fabrication difficulty, and sensitivity to process variations at nanoscale. This review presents the LDO architectures, optimization techniques, and performance comparisons in different LDO design domains such as digital, analog, and hybrid. In this review, various state-of-the-art circuit topologies, deployed for the betterment of LDO performance and focusing on the specific parameter up-gradation to the overall improvement of the functionality, are framed, which will serve as a comparative study and reference for researcher he level of integration of modern electronic circuitries has increased in the last few years, because of the advancement of complementary metal–oxide–semiconductor (CMOS) technology, resulting in compact as well as low-cost electronic appliances [1,2]. The rapid growth of CMOS technology enables lower power supply operation, which helps to attain reduced power dissipation in the circuit and a minimalized fabrication cost because of the compact chip size. CMOS offers the prospect of integrating radio frequency (RF), digital, and analog functions on a single chip in a low-cost manner by eliminating the need for different external components [3,4]. Along with the advantages, the CMOS has also brought up some inevitable challenges for the designers, which include short channel effects, gate leakage, fabrication difficulty, sensitivity to process variations at nanoscale, etc. [5,6]. With the

adaptation of the internet of things (IoT), battery-powered devices such as mobile phones, personal digital assistants (PDAs), and smartwatches are nowadays gaining much popularity around the world. Power management has become a more significant issue to improve a device's battery run-time, which necessitates efforts from the A linear regulator circuit is used to regulate an output voltage, which includes a first current path to conduct a first current, a feedback path to provide feedback and maintain a constant output voltage, and a transistor positioned in the first current path to afford the output voltage [11]. While large power transistors are charged and discharged by the driver, switching losses can incur. A linear regulator has low drain efficiency, which indicates that the output power dissipated as heat in amplifiers due to the average DC current is minimum. Therefore, the load network and DC biasing has little impact on device performance that elongates the linear regulator's effectiveness. A linear regulator can provide high-speed variations in the output signal and can generate a faster load transient response. Moreover, it causes poor performance in current efficiency when the low drop output is large [12–17]. Linear regulators can yield regulated low noise and precise supply voltage, which makes them a crucial power management module, as shown in Figure 1. The functionality of an LDO becomes noteworthy when there is a low voltage difference between the input and output. The drawback of linear regulators is that they primarily reduce the power efficiency that can be measured by the regulation FET's dropout voltage [18]. Several conditions such as external compensation of the regulators, output capacitance, and parasitic capacitance of resistance. There are various parameters for the gross evaluation of a linear regulator, namely, dropout performance, quiescent current, line regulation, load regulation, transient response, power supply rejection ration, die area, and power consumption. Moreover, researchers integrating significant parameters of their design to specify a compact effect of their design propose several mathematical approaches. This review presents an overview of the design strategies reported in the literature to build high-performance linear regulators, especially low-dropout (LDO), that are proven as convenient for versatile applications.

Traoré, J., "An Introduction to Electronic Voting Application to Single Transferable Vote", Orange Labs, July, 2014.

This paper describes the Official voting system by electronic ballot: E-Vote, which aims to streamline primary electoral processes performed in the country, beginning with the District Federal benefits and improvements. The principal benefices are economic and ecological time, taking into account process security features and the integrity of the captured votes. This system represents an alternative to the currently devices and systems implemented in countries like Venezuela, Brazil and the United States, as well formalized as a prototype able to compete with others developed by the Institute Federal Electoral District (IEDF). The use of computerized systems in electoral processes is not new. Although certain actions are still made by hand, others have sophisticated technology. For example, aggregation of results is typically done electronically, although remaining paper backing can be checked with the provided data. Thus, the electronic voting studies normally do not cover the phases and the computing process. But the introduction of electronics in the electoral process kernel, is the moment at which citizen people emit their vote. Currently, this is done by introducing a paper sheet vote into an urn. It can be possible that such operation can be computerized. Precisely, our approach adopts narrowly this kind of electronic voting and analyzes various forms to perform it. While a controlled environment, as current boxes, we can not exclude the possibility of immediate coercion, voting from home or from the

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www.ijasem.org

Vol 18, Issue.2 April 2024

workplace leaves the door open to possible extortion. Electronic voting present many advantag they make faster and more agile counts and ratings long are cheaper. Despite all the benefits, many experts believe that the main vulnerability of electronic voting is the integrity of the vote, that is, the voter is satisfied that Your vote will be counted as the did. Having taken into account this problem, have sought various solutions to this, ranging from the total suspension of use of electronic voting to implementation and testing of better secure systems.

Drexler, J., and Dyball, C.J., "Anti-Fraud Voter Registration and Voting System using a Data Card", Google Patents, 1995.

The ultimate goal of democracy is to "vote" in which people can choose candidates for a functioning government to meet their needs and demand that their quality of life be improved. In developing countries such as "PAKISTAN", the ECP follows manual voting mechanism which is done by the ballot boxing. The total number of registered voters in the 2018 elections was 106,000,000 but the total number of votes was 53,123,733 which means that 50% of the votes were not opened or abolished due to the manual system. Therefore, the machine was required to make the process work automatically. The machine is placed in the poll booth center and supervised by senior management, due to some illegal activities the polling station is abused and human rights are denied. The biggest problem is that people do not leave the area where they are registered as voters or do not go to the polling station for any other reason. The queue at the polling station is one of the main reasons for the low percentage of voting. Some people vote, and about 2% of the vote always becomes invalid, for whatever reason. To overcome all the problems of traditional voting methods, we have come up with a new solution to solve all the problems discussed above.Fingerprint Based Voting System is a system in which the user is identified by his or her finger pattern or IRIS (or other biometric in the future). Since the pattern of each finger is different, the voter can be easily verified. This system allows the voter to cast a ballot with his or her fingers. Fingerprints are used to identify the user specifically. Fingerprints are used as voter confirmation. A voter may vote for a candidate only once, and the system will not allow a candidate to vote a second time. The system will allow the administrator to enter the name of the candidate and a photo of the candidate to be nominated. Only administration has the right to add the name and photo of the nominated candidates. The number of entries by the administrator will be automatically deleted after the election has been completed. The presiding officer must add a date for the end of the election. The system will allow the user to vote once in a particular election. The admin may add any number of candidates for the new election. The administrator can view the election results using the election id. We have built this program in an accessible way with a low level of hardware. Biometrics statistical analysis to measure biological data. Refers to the technology that calculates and detects elements of the human body, such as DNA, fingerprints, retina, irises, voice or any other sound patterns, facial patterns and measure of hand gestures, for the purpose of verification.

In our study, we used fingerprints for voter identification and verification. Since each person has different finger patterns, it helps to achieve high accuracy.

A database is developed that stores fingerprint of every individual in the constituency. Elections will therefore be conducted fairly and without crime.

"Finger-based voting system" is a system designed to help the user to vote smoothly and efficiently.

- The Voting system will have server services which are each connected to a remote link database for storing persistent data.
- Admin will maintain all information regarding voter and responsible for fair conduction of the elections.

Sehr, R.P., "Computerized Voting Information System Having Predefined Content and Voting Templates", Google Patents, 1999.

Since, India being the largest democracy in t he world. Still uses voting machines to hold e lections, which comes with high costs and m anual labour. But voting plays a crucial role i n the election of high-ranking government of ficials and reflects our view of how a govern ing body should be formed. Investigations ar e conducted from time to time to troubleshoo t the central voting system, increasing anony mity, credibility and security while preventin g all types of fraud. In this paper, there is an implementation of a method that uses deep le arning techniques which develops a smart vo ting system. Due to its advanced features, m ost researchers follow and use the Boosted C ascade framework. The enhanced Cascade Fr amework features help you calculate and bui ld a classifier that works more accurately. Ho wever, this accuracy rate requires a large nu mber of Cascade Stages to help reduce simil ar performance with the detection and recogn ition accuracy. This provides protection in th e sense that the most secure voter password i s verified before a vote is received on the ma in database of the Indian Electoral Commissi on and voters can verify that his or her vote h as reached to correct participant of election. The votes counting is done automatically, th us saving a lot of time and the results can be announced in a very short time by the Indian Electoral Commission. The user verification process is enhanced by adding a face recogni tion to the app that will determine whether th e voter is a certified user or not. In India, bei ng voting system as online is a way for the p eople to elect their representatives and expre ss their preferences on how they will be gove rned. It is very important to have belief in th e electoral process. The electoral process is s ecure in the event of an election irregularity a nd the system will increase security levels. B ut there is a possibility of Maoist attacks and fraud problems in some areas, there is a chan ce of losing votes and their lives. So the publ ic needs a more secure voting system. Electi ons are a process by which people can talk a bout their political feelings. They express the se feelings in an open democracy to elect a p olitical pioneer. Besides, the political pionee r would have a responsibility, authority, and j ob. As we can see that election is a conventio nal cooperative choice creation procedure. A dditionally, the chosen political pioneer wou ld hold an open office. The political race is a n important pillar of many legal systems. Thi s is on the grounds that; Election gives guara ntee that the administration is of the individu als, by the individuals, and for the individual s. Constituent frameworks are having point b y point protected plans and casting ballot fra meworks. These step by step established idea s and voting structures turn the vote into a po litical decision. The expected approach is to establish a firm online voting system using f ace recognition aimed at overcoming all dra wbacks that occur in the existing voting syst em. The proposed system has many powerfu l attributes such as accuracy, reliability, com fort, etc. In this system, there is no need of a n electoral officer, a ballot paper or any othe r electronic voting system but only a strong c

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Vol 18, Issue.2 April 2024

onnection of internet and face scanners are e ssential where one can vote from anywhere.

PROPOSED SYSTEM

In this section, a brief description of various hardware units is presented that are integrated in proposed project to achieve the improved results for the proposed electronic voting system, as shown in Fig. 1. Microcontroller: A microcontroller can be defined as an integrated circuit that contains a core processor and memory [16]. Microcontroller is also known as an embedded system, capable of storing, processing and transferring data and information between various peripherals interfaced with it on some logic, i.e. like a coordinating body of a circuit. With the advancement in the field of electronic technology especially in microelectronics and embedded system development, various development boardsare available. These boards include Arduino-UNO, Texas Instruments MSP 430 Launchpad, Nanode, Pinguino PIC 32, Teensy 2.0, Raspberry Pi and many others. These boards not only provide microcontroller facility to the end user but also an interfacing capability to connect different devices i.e. Bluetooth, Zigbee, LAN and WLAN (Wireless LAN also called WiFi). The proposed system (in our research) uses Arduino-UNO board due to good processing speed as well as memory, and capable of interfacing, controlling and monitoring of data flow Fingerprint Module: Unique finger impression recognition or fingerprint authentication indicates the mechanized strategy for checking a match between two human fingerprints [18]. The examination of fingerprints for coordinating purposes requires the correlation of components of the print design. The extracted parameters of a finger pattern include edges and minutia focuses [19]. These distinct features of a biological pattern give uniqueness to a human being. The mechanized method for the verification of a fingerprint is done by using an electronic device called Fingerprint Verification Module, which captures the unique pattern of a fingerprint in the form of a computerized digital image. The digitally captured images are then processed to prepare a biometric template. This biometric layout is an accumulation of extricated elements which is stored and utilized for coordinating and matching [20]. The proposed system uses a finger print verification module developed by Future Electronics Egypt. Facial Recognition System: Facial recognition system or facial acknowledgement framework is defined as an application capable of detecting and recognizing a person from a digitally processed image [21]. This unit comprises of facial recognition algorithms which includes facial detection, facial feature extraction, formation of biometric template by compression and formation of Eigen vectors and their comparison. Many popular facial recognition algorithms are available in literature that include PCA (Principal Component Analysis) using Eigen faces, LDA (Linear Discriminate Analysis), Fisher-face algorithm andDynamic link matching [22]. The proposed system incorporates the facial recognition algorithm, developed by [23]. The details of the algorithm and its working details are provided in the next section of this paper. A flow diagram of the proposed algorithmic setup is shown in Fig. 2. The input image is processed to be utilized by trained classifiers that produce a final decision of either recognized or unrecognized.

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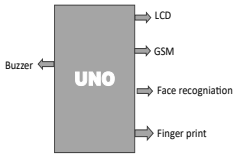
www.ijasem.org

Vol 18, Issue.2 April 2024

Block Diagram



ARUDINO:

The Arduino is a family of microcontroller boards to simplify electronic design, prototyping and experimenting for artists, hackers, hobbyists, but also many professionals. People use it as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standard Arduino Uno) are built around an ATmega microcontroller — essentially a complete computer with CPU, RAM, Flash memory, and input/output pins, all on a single chip. Unlike, say, a Raspberry Pi, it's designed to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts. The Arduino connects to your computer via USB, where you program it in a simple language (C/C++, similar to Java) from inside the free Arduino IDE by uploading your compiled code to the board. Once programmed, the Arduino can run with the USB link back to your computer, or stand-alone without it — no keyboard or screen needed, just power.

GSM (Global System for Mobile communications)

GSM (Global System for Mobile communications) is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in four different frequency ranges. Most GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated.

BUZZERS

In common parlance a Buzzer is a signaling device that is not a loudspeaker. It can be mechanical, electromechanical, or electronic (a piezo transducer). BeStar produces Buzzers in every available configuration for a wide variety of applications. A Piezo transducer can produce the sound for panel

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www.ijasem.org

Vol 18, Issue.2 April 2024

mount buzzers, household goods, medical devices and even very loud sirens. When a lower frequency is required an electromagnetic buzzer can fill the need. These are very common in automotive chimes and higher end clinical diagnostic devices. The BeStar buzzer range includes self drive units with their own drive circuitry (indicators), or external drive units, which allow the designer the flexibility to create their own sound patterns.

CONCLUSION

A novel hybrid biometric voting system is proposed, implemented and analyzed for fair polling process during general elections in developing countries including Pakistan, Nepal, Sri Lanka and others. The investigation results show91% accuracy of the proposed system. With the implementation of GPCA and KNN cascaded classifiers that are discussed in the previous section of the paper. Additionally, the proposed system also involves the finger print based security feature to provide additional authenticity of the voter. The future work will be to incorporate security features in the proposed system by introducing encryption algorithms.

REFERENCES

[1] Bhuiyan, M.S., Rehman, M.M., and Hossain, M.R. “Electronic Voting System”, B.Sc. Thesis, Department of Computer Science & Engineering, , BRAC University, Dhaka, Bangladesh, January, 2007.

[2] Traoré, J., “An Introduction to Electronic Voting Application to Single Transferable Vote”, Orange Labs, July, 2014.

[3] Whither Biometrics Committee, “Biometric Recognition: Challenges and Opportunities”, National Academies Press, 2010.

[4] Drexler, J., and Dyball, C.J., “Anti-Fraud Voter Registration and Voting System using a Data Card”, Google Patents, 1995. [5] Sehr, R.P., “Computerized Voting Information System Having Predefined Content and Voting Templates”, Google Patents, 1999

[6] Tagawa, K., “Electronic Voting System”, Google Patents, 2010.

[7] Evertz, G.P., “Electronic Voting System”, Google Patents, 2009.

[8] Azougaghe, A., Hedabou, M., and Belkasmi M.,”An Electronic Voting System Based on Homomorphic Encryption and Prime Numbers”, 11thInternational Conference on Information Assurance and Security, pp. 140-145, 2015.

[9] Awad,M., and Leiss, E.L., “The Evolution of Voting: Analysis of Conventional and Electronic Voting Systems”, International Journal of Applied Engineering Research, Volume 11, pp. 7888-7896, 2016.

[10] Alomari, M.K., and Irani, Z., “E-Voting Adoption in a Developing Country”, Transforming Government: People, Process and Policy, Volume 10, 2016.

[9] Karne, R. K. ., & Sreeja, T. K. . (2023). PMLC- Predictions of Mobility and Transmission

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

in a Lane-Based Cluster VANET Validated on Machine Learning. International Journal on Recent and Innovation Trends in Computing and Communication, 11(5s), 477–483. https://doi.org/10.17762/ijritcc.v11i5s.7109

[10] Radha Krishna Karne and Dr. T. K. Sreeja (2022), A Novel Approach for Dynamic Stable Clustering in VANET Using Deep Learning (LSTM) Model. IJEER 10(4), 1092-1098. DOI: 10.37391/IJEER.100454.

[11] Reddy, Kallem Niranjan, and Pappu Venkata Yasoda Jayasree. "Low Power Strain and Dimension Aware SRAM Cell Design Using a New Tunnel FET and Domino Independent Logic." International Journal of Intelligent Engineering & Systems 11, no. 4 (2018).

[12] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Design of a Dual Doping Less Double Gate Tfet and Its Material Optimization Analysis on a 6t Sram Cells."

[13] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Low power process, voltage, and temperature (PVT) variations aware improved tunnel FET on 6T SRAM cells." Sustainable Computing: Informatics and Systems 21 (2019): 143-153.

[14] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Survey on improvement of PVT aware variations in tunnel FET on SRAM cells." In 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC), pp. 703-705. IEEE, 2017.