A Detailed study on Applications of IoT in Higher Education System

[1*]Siva Shankar S, [2.]Dr. V. Anantha Krishna, [3.]Ravikiran K, [4.]E.Sreedevi, [5.]Dr.D.Vijendra Babu, [6.]Dr. M. Tholkapiyan

[1]Department of Computer Science and Engineering, KG Reddy College of Engineering and Technology, Chilukuru village, Moinabad, R R Dist, Telangana

[2] Professor, Department of Computer Science and Engineering, Sridevi Women's engineering college, Hyderabad.
[3] Associate professor, Department of IT, Gokaraju Rangaraju Institute of Engineering and Technology.
[4] Department of C.S.E, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A.P, India – 522502
[5]Professor, Department of Electronics & Communication Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission's Research Foundation,Paiyanoor-603 104, Tamil Nadu. India.
[6] Professor, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, 602105, India.

*Corresponding author mail: drsivashankars@gmail.com

Abstract

Higher Educational Institutions are adopting new Internet of Things technologies as a parts of the educational system.IoT seems to be the possible solution for rapid educational changes and technological advancements.Implementation of Internet of Thingsin the Higher Educational Institutionsis necessary to sustain in the educational system. IoT-based Higher Educational Environment can provide smartness through Automation and provide efficient operation, monitoring, and maintenance of the classes' routine activities. Different literature works were collected and reviewed to understand the progress of IoT implementations in the Higher Educational Institutions. This paper surprisingly came across various new ten domains with the trend set of forming the concept of invoking Automation and Intelligence in the Higher Educational Environments. This study finally explores and concludes that experimentations on intelligent classroom frameworks and embedded devices such as IoT or mobile devices will enhance the experiences of the future classroom models.

Keywords: Internet of Things, IoT Applications, Raspberry Pi, Higher EducationInstitutions

INTRODUCTION

Higher Educational Institutions are integrating various educational technologies into their educational space. Educational transformation is becoming a trending jargon through Computer and Telecommunication. Even though technologies are getting adopted, microcomputers are yet in the starting stage of effective integration into the Educational sector. From the past two decades, Works from Researches of various fields show that they have not yet succeeded in developing a complete solution for integrating educational technologies into the academic environment. Various challenging factors, such as Space, Cost, Availability, Reliability, Support, or knowledge, matter while considering their adoption. Thus, it is necessary to go for a better and promising solution to fill these heterogeneous gaps. Here comes the Technology called IoT- the Internet of Things. Nowadays, Automation has become a trending context to refer to smartness in our everyday life. With the help of IoT, which can act as a medium to interface physical and virtual worlds by computation of the embedded objects present in them through Automation. But bringing intelligence along with Automation will stream an excellent start for the future generations to work. IoT concepts integrated with connectivity, sensors, data

analysis, and making decisions based on the results can simplify many real-time problems in the Classroom where many students gather more often. IoT will increase our everyday routines through intelligent and robust systems, making our lives fast and easy regarding our priorities and preferences. An IoT-based Higher Educational Environment can provide smartness through Automation and provide efficient operation, monitoring, and maintenance of the classes' routine activities. When we look into the difference between the context "smart" and intelligence, the former is one where the content's delivery is quick and automatic. However, in the latter, the delivery of the content cannot be immediate. However, it will be very efficient and operational, i.e., it can provide users with what they are trying to do using some computational works."A picture is worth a thousand words," like our vision, a digital concept called Computer Vision came into existence that captures and stores an image or image sets, then transforming them into meaningful information to make interesting decisions. Our eyesight is one of the essential and brilliant creations of God among our sensory systems. In general, it is a fact that our surrounding environment is composed of various visual signals or signs (cues). In Higher Education, Physical cues may be Student Classroom Activities, Teaching Activities, Student Engagement, Academic Performance Activities, Administrative activities, Monitoring and Maintenance Activities, etc.Computer Vision Engineering comprises interdisciplinary fields such as Artificial Intelligence (AI), Machine Learning (ML), Image Processing, Sensor Technologies, Augmented Reality, Robotics, etc. In the recent past, the application of CV technologies was performed on some closed source platforms. Computer Vision (CV) applications in Higher Education will date back to the 1980s. As in combination with IP-based technologies, a new set of implementations, environments, or systems were created that were not made possible before, resulting in a revolution in IoT innovations. Once we are ready to connect devices with the concept of IoT, then there arises the next step towards making things more intelligent by generating actionable data for better valuable insights. Apart from the theoretical knowledge, the future and the full potential of any technology lies in its implementation. Various IoT prototyping platforms have been introduced, such as Arduino, Beagle board, Intel, Raspberry Pi, etc. The Raspberry Pi platform has been considered for its state-of-the-art related works andtechnologies in this review work. This review paper investigates how effectively IoT and Computer Vision can create an intelligent educational environment promoting Automation and intelligence, thus impacting higher education. Towards the realization of this objective, the proposal aims to survey the literature works related to the different methodologies and styles of IoT and CV principles or technologies adopted into Higher Educational Environment in essence with constructing automated intelligence based IoT systems. Thus, enabling a quick start in providing Automation in educational institutions, especially in classrooms where the students gather more often than in other areas. IoT based Automation has become a developing research area to emphasize students' importance of the technologies that will rule futuregatherings.

Educational Technology has its primary purpose of serving the entities of the educational infrastructure. Therefore, its usage in Higher Educational Institutions (HEIs) has become a trend in this digital era. When a technologist named Kevin Ashton from Britain coined the term “Internet of Things" in 1999, he would have known that IoT will become so popular, forming a remarkable age called the "IoT Age," making ourselves the IoT Generations. The educational History of IoT dates back to the 1980s, with the brief history of IoT use cases in Higher Education is discussed as follows. As said by Mark Weiser [1], The most in-depth technologies are the ones that fade away”, i.e., computational processing will be invisible, whereas the information processing will overwhelm surrounding us. In this context, we try to focus on IoT in Higher Education where “Things” include objects that are not only the electronic devices or the products of any higher-level technological developments (i.e., vehicles, appliances, equipment) but also things that we ordinarily use around us such as a chair, table, etc. inside the educational environment. IoT's supreme goal is to make things connected at any time, with anything, and with anyone using any path or any services [2]. Automatic machines can reduce workforce work, along with perfection [3]. An overview of various IoT contexts applicable to Higher Education is discussed below in the fig1.

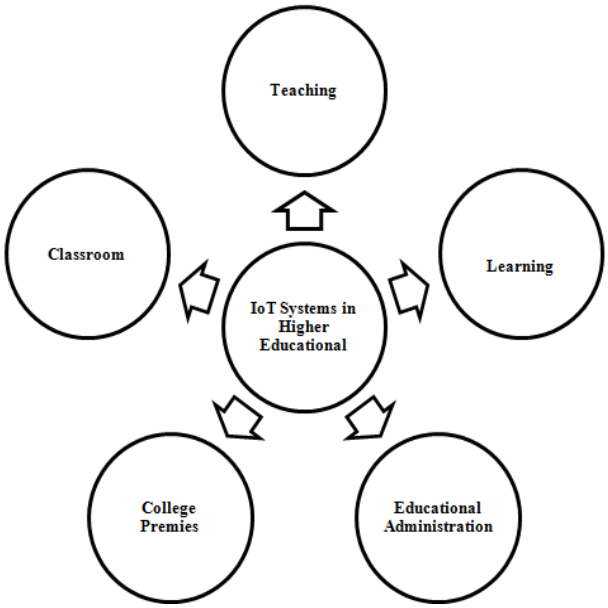

Figure 1. IoT Systems in Higher Educational Environment

Teaching. Teachers are the primary focus, with students considered to be secondary.When we influence teaching through IoT by concentrating on new pedagogical techniques and approaches [4], Smart teaching methods useful for IoT implementation such as [5-8], and how to make a smart classroom [9], promotion of ubiquitous learning using a mobile-based personal device, positive effects on ICT by enhancing education process and learning effective and motivate[10].

Learning. A smart learning concept [11] based on context-aware ubiquitous learning methods for a good learning experience, learner-centric, and service-oriented educational paradigm without just focusing on the learning devices [12]. Learner engagement and independent learning can be made possible through richer contexts and augmented techniques; in contrast, smart devices supportsmart learning and intelligent technologies [13], record lecture data and share it with e-learning platforms [14], Student-centered learning methods through projects, problems of discovery, etc. were discussed [15], better learning through connected devices [16], more collaborative e-learning becomes vital with IoT[17].

Educational Administration. With IoT, the admin can maintain the student's attendance record [18], students, as well as teachers, can identify their presence with smartphones [19] to perform learning analytics on the educational data of student's learning activities [20], various contexts arise for smart education. For example, by sensing eye gazes, emotional stress, and motion detectors for gesture detection and different neurological parameters were analyzed to monitor them effectively [21]; through multimodal learning analytics, sensors can be placed inside the Classroom to potentially record the activities such as temperature, capture audio feeds, a wearable wristband to sense their biological factors effects, motion capture sensors to sense hand, eye, head, facegestures [20].

College premises. Various studies are made through IoT to create smart environments in [22-24]; there were studies on how e-learning data be captured and analyzed to improve teaching and to learn through personalized learning [25]. Electronic equipment such as printers, scanners be integrated with bar codes and QR tags for better identification, integrating embedded devices or UID to interact with intelligent network structure to monitor objects [26], monitoring parking slots and several vacancies, users can give message alerts to reduce security violations, users can use air monitors to reduce noise pollution, garbage collection systems, auto water flows in gardens, teachers can use e-books with 3D modeling of the image using QR codes in libraries.

Classroom.A teacher can maintain control over the Classroom with IoT by identifying student engagement or interest by determining the concentration levels [27]. After lectures are given, real-time feedback on the quality of the courses be arrived [28], intelligent Classroom with tele-education methods [29], automatic adjustment of lights in the Classroom, RFID tags with student ID cards [30]/ in entrance of campus [31] or student-teacher classroom relationship enhancement [32], transform the dumb classroom-technology that require human control to smart space as "intelligent classroom" with ubiquitous computing and ambient intelligence[33].

Applications of IoT in Higher Education: The below-mentioned diagram can give a brief skeleton of ideas about IoT that can be implemented in Higher Educational Institutions.wesaw various impacts of IoT in different educational infrastructures in figure 2.

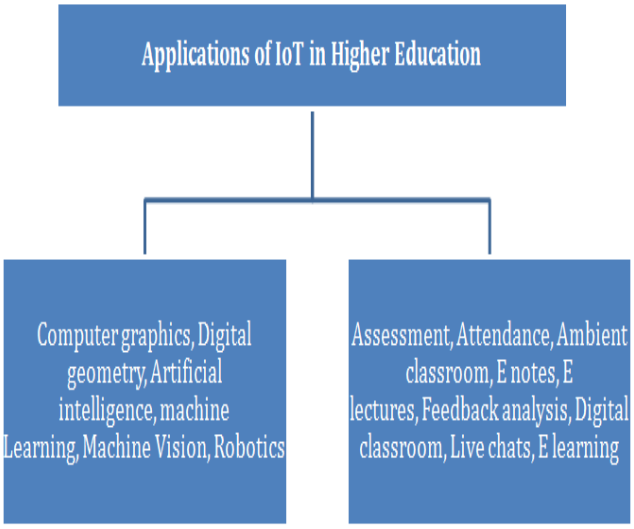

Figure 2. Applications of IoT in the Educational environment.

LITERATURE REVIEW

There are many papers available in the fields mentioned above. However, for this review work and constrained time limit, only 200 papers related to the above mentioned technologies were explored, collected from Google Scholar, IEEE Xplore, Academic papers, Researchgate, Academia, Journals, Conference proceedings, etc. Automated intelligence is a unique stream in which a particular software or hardware can automatically do the task or things without any human intervention. But Automation alone cannot make a job very easy to be completed. On the other hand, it makes it more efficient, and decision-making has to be done by the system without human instruction. There comes into the picture "Intelligence." So, Automation can or cannot be necessarily an artificially intelligent system, i.e., an Automatic system can be artificially intelligent, or it can be asystem with program fix instructions. It depends on the system-specific requirements. Artificial Intelligence is a branch of science that deals with computer program development using several algorithms such as problem-solving, logical reasoning, tackling perceptions, learning, and understanding the language. In simple words, Through Automated intelligence, Smart systems can be transformed into intelligent decision-based processing systems. Papers related to IoT based Automated Intelligence are very few and yet in the developing stage. Current research papers focus on how IoT devices/ objects can be identified, connected, and managed. In this study paper, an attempt has been made to enhance how IoT devices can be worked with intelligence.

IoT technologies experimented in Higher Educational Institutions (HEIs) were listed from the year 1989 to 2018. In 1989, Arthur Leuhrmann made an Intellectual Amplifier. Similarly, Janette et al. (2000) tried using Ubiquitous computing devices for teaching, learning, communications, and portable technologies. With the same context, Bryan Alexander (2004) has a ubiquitous e-learning environment using mobile devices in a higher educational environment with wireless technologies. Later, A Student Educational Device (SED) was prepared on interaction with smart classrooms using Wi-Fi devices offering assignments, classes, textbooks, and videos by KevinMcREynold(2008).In (2009), Smart e-learning system and HCI based on polka dots and color band pattern recognition and Augmented Reality using Speeded up robust features for feature extraction techniques. Swati Vitkar (2012), to e-learning over a cloud environment, ubiquitous devices were tried to communicate through cloud networks. Ubiquitous Scientific DeviceTransfer (USDT) using RFID tags and Context-aware ubiquitous learning with sensing Technology to analyze real-world students' behavior in Gwo-Jen Hwang (2012). In 2013, Usage of ubiquitous computing devices such as Pad-type appliances, interactive whiteboards, tele-presentations using cellular, NFC, Wi-Fi, or Bluetooth inside the Classroom. In the same year (2013), holography (3DHT) is used as a learner's stimulus agent in the smart learning environment, was introduced. Thus, an educational framework is where everything in the academic domain is automated and associated with pervasive computing related to the cognitive domain.Similarly, (2013), Gopinath et al. used PyBlueZ, a python library module, to connect Raspberry Pi via HDMI to a touchscreen interface using Bluetooth 2.1 dongle along with a calibrator program of Xinput-calibrator using Radio Frequency Communication Protocol. Uganda et al., in 2013, tried to study the development of Epi-prototype as an educational tool for using Raspberry Pi in the educational sector, especially in Uganda, to teach science, computing, and engineering. A scenario of setting temperature sensor and ADC converter through GPIO pins in Epi to implement a digitaladvertising board.

REVIEW ANALYSIS

Valeriu Manuel IONESCU et al. (2014), based on GPIO sensors with Oracle JDK 1.8 based on Multiple Client Single server communication over TCP/IP

and user interface, was added to support usability to secure data transfer AES algorithm was also implemented. Folakemi et al. (2014) tried using pervasive computing devices like PDA's, wearables, display boards, etc., with 3D printing, Games, Virtual Assistants, Daily Self-trackers. AR-based games can be created, made possible by (Boris Pokric et al.) using Environment monitoring using ARGenie and ekoNET platform integrating IoT solutions with AR-based games on a CoAP network. In 2015, 3Dholographic Technology (3DHT) is used for teaching and learning environments. Like Valeriu's work, a remote digital advertising board with Raspberry pi 3 model B dividing the system into multiple levels and regions and numerous screens is also used for LCD via HDMI with back-end PHP and front-end HTML5 bootstrap. E-learning environment with ubiquitous devices and systems by (Matthew Montebello et al., 2017). Majid BayaniAbbasyet al. worked on Descriptive, theoretical research on IoT with Education, forming a novel Internet of Educational Things model (IoET). Various features of IoET were statistically analyzed, such as classroom engagement, Creativity, e-Learning, self-learning, research opportunity, collaboration, etc. MirjanaMaksimovic et al. (2017) developed his work on Collaborative based IoT supported education in a classroom environment with IoT-enabled devices such as Interactive whiteboards, Smart document cameras. Jay R.Porter (2017), Building Automation with IoT Building Monitoring Device (IBMD) along with3D printers is introduced to teachers and students with various STEM concepts using Edukas Model, Ant Colony Optimization, Random Forest, and Principal Component Analysis.

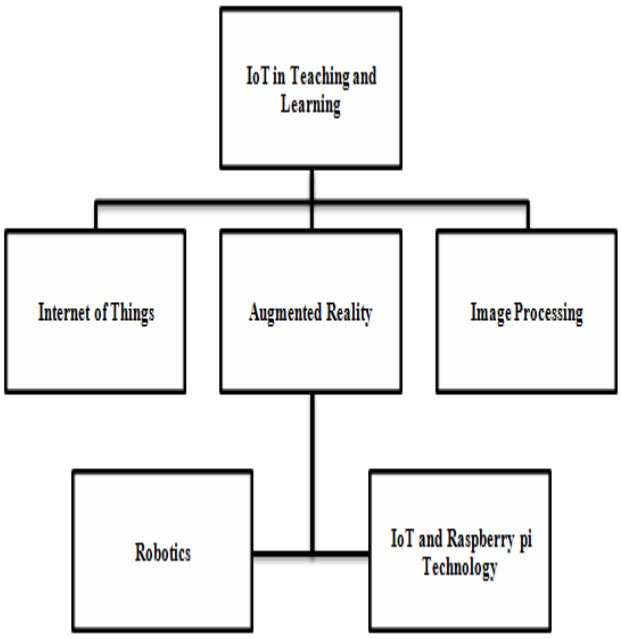

Figure 3. IoT in Teaching and Learning

In 2017, Luka Petrovic et al., Web-based application using PHP and Laravel 5.3 framework, MYSQL along with RFID tags and QR codes on Moodle LMS interconnection with plant watering scenario and Vuforia task to recognize Raspberry pi system and complete IoT schemas to test knowledge on the subject by assigning tasks of different difficulty levels. Works related to combining AI and AR for teaching and learning practices by Stefan A. D. Popenici et al., Fernando Moreira et al. also worked on a Conceptual approach to enhance the learning process of TLP in higher education by deploying IoT, Big Data, and Cloud Computing technologies. A Smart advertising board by Togo, Similar to Valeriu's work, implemented Raspberry Pi on a Wi-Fi connection via HDMI display. A GUI-based web page is created using PHP language MYSQL for database communication. From a teacher's perspective, trying to evaluate the students' attention inside the Classroom via RFID for an indoor positioning systemby RawiaBdiwiet al. (2018). Ana-Maria SUDUC and Shahbaz et al. investigatedenhancing teaching and learning using various IoT technologies in education. Using EDM(Educational Data Mining) techniques concerning Student's profile, Learning content customization, Performance predictors, concept maps, courseware construction, classify characteristics, Undesirable behavior, Group students, Social Network Analysis, Intelligent Systems for instructor feedback, etc. to help educators in making decisions related to

students' academic performances based on the data generated with Binary Edge Detection Method, Adaptive thresholding, Ellipse fitting method, Pixel sampling, Running video Average. Sensor technology to track 3D objects by Diego Lǒpezde Ipiña and QR codes to implement higher education as QR codes-based textbooks, geolocation-based information display, camera name, and place ratings are displayedAshmitKohli (2018). The above analysis is based on the references[64-95].

A. **Augmented Reality:**To possibly see the applications of Raspberry Pi and Augmented Reality, Virtual Reality, and 3D, it is visible that in recent years, various works have been done such as in 2015 and 2017, Augmented Reality has been used with wearable devices to create teaching and learning environments by Suvarna et al., Dharmateja et al., Nikhil et al., and Sűleyman et.al. A Model to combine Computational Experiment along with Computational Thinking with physical computing environments connecting Ejsor Scratch in Raspberry Pi for inquiry-based learning activities with STEMepistemology practices by Sarantos (2017), Energy Monitoring system by Jannish as interfaced with Computer Vision and AR using Node-Red tool and Influx DB, TP-Link HS110, MQTT. A Novel Mobile learning with Augmented Reality using 3D models with Motion Estimation, Page Determination, Text Recognition, Model Rendering modules with OCR to explain theoretical concepts by Xunyu (2018). Iain (2004) tried his work on Blind WA in combination with Cisco Systems deploying 3D sound models, Hapticsystems, and Braille concepts along with visuospatial concepts for vision-impaired students with easy access to learning materials. Low-cost tablets for rural students by Putjorn (2015), Video streaming with holograms (2017). The above analysis is performed from the references[96-103].

B. **Image Processing:**While focusing on Image Processing algorithms, An Android-based educational tool (Mobi4Ed) is used to study the Image/Image Processing algorithms with the client as Google Nexus and Server with Intel Xeon CPU and Windows Server 2008 R2 running OpenCV with Visual C++ by RomyFerzli et al. (2011). They detect laser spots with OpenCV Library by capturing an image through a webcam installed and connected to the USB port on Raspberry Pi. It can be used against a computer-based image processor system (Aryuanto et al. (2014)), A real-time finger gesture recognition by Geraldine (2015), Similarly in 2015, Novel technique to control wheelchair remotely based on eye movement for disabled persons based on image processing techniques at different stages such as Eye detection and Face detection, Edge detection, color conversion, Hough Transformed, motion detection and object tracking on OpenCV library installed on Raspberry Pi (Shyam et al.), In the same year, Varsha tried to detect the vigilance of drivers using real-time image processing and computer vision techniques with automatic alarm systems. Qifan proposed a novel method to detect fall alarm and abnormal inactivity of older adults using Computer Vision and Image processing techniques, an alert is sent through SMS or mail through TCP/IP protocol. Hassna, in 2015, Embedded agent for CardiacMRI images along with Java Agent Development (JADE) platform for multi-agent system construction. It is implementing a Parallel algorithm with the C-means method executed on Raspberry Pi 2 devices. In 2015, Marko proposed a multi-camera-based remote surveillance system supporting images with 1080 pixels consisting of a 10- second refresh rate. Raw photo is taken using a tool called raspiyuv. Image is compressed with Kvazaar HEVC encoder to output HEVC image in BPG format. These images were broadcasted over camera nodes to terminals over the Internet with Web SocketProtocol and a client-server model with an idea broadcasted to the client through node.js and the client receiving images infull-duplex communication without polling. QR codes on integration with Raspberry Pi with image processing techniques and UVC Camera driver and Open CV library on TFT_LCD display by P.V.Vinod et al. (2015). Digital image processing for road sign recognition system with embedded computing platforms such as Raspberry Pi, Capture images with OpenCV libraries, and Image processing algorithms such as OpenCV Contour and Edge detection, Optical Character Recognition run on Ubuntu MATE with GPIO pins interaction with a Camera module. k-NNfor feature classification and geometric space by Enis et al. (2016), (Jyoti) in 2016, proposed Wi-Fi-based photography using hand gestures.

C. **Robotics:**In the Robotics area, few papers were surveyed as mentioned below; Keerthi et al. (2015), the Robotic arm is used with Raspberry Pi with 15 GPIO pins interfaced by controlling the joints of the robotic arm and its movements through Android application with the Wi-Fi connection. Morgane et al., in 2017, proposed an

educational robot such as the Thymiorobot has been studied to determine how its usage been perceived by the teachers in education. A Collaborative Robotic Educational Tool with the main module FGPA communicates with Smart devices via Bluetooth, with secondary module integration with Arduino shields. External elements included such as Servo management, motor control, memory., etc. They have also provided scenarios to implement in educational activities such as 4-wheeled robot arm, Educational drones, Educational Environment, Smart Devices, remote Internet playground, Pedro et al. in (2016).

D. **IoT in Teaching and Learning:**While in the recent advancements, Nikolas et al. (2014) proposed a model integrating Raspberry Pi and its software to teach Physics concepts through lessons, e-books, experiments, code examples, etc. along with PHP/MYSQL on Linux with better user interfaces possible by JS/jQuery, AJAX, JSON, etc. emphasizing on its importance to use Pi in educating schools as well as college students at various distributed subjects with scientific proofs. Again, in the same year, A Clustering of 8 Raspberry Pi Boards in the form of parallel supercomputers along with Ethernet, USB with slave nodes for power supply and master nodes for keyboard, mouse, display connections forming the PiBrain to educate students in concepts of Introduction to Programming supercomputers at a minimal cost running on an ARM processor. It utilizes MPI (message passing protocols) for communication in parallel programming models by P.Turton et al. Rebecca et al. (2016) examined the classroom applications of Rpi in teaching Database management courses, computer architecture courses, Computer organization courses as a prerequisite for teaching IoT technology based on active learning projects with a computer lab set up for Rpi in a test-bed environment. Diyana et al. (2015), For a virtual laboratory, Raspberry Pi acting as a console server for remotely accessing communication devices following steps such as serial port selection, Serial port configuration based on Speed/Band rate, Number of Bits, Parity, Number of Stop Bits and Flow control, etc. thus enhancing the education in the computer science fields and its correspondingly related subjects. Investigate teacher's reaction towards CPD (Continuing Professional Development) program with Raspberry Pi to enhance circuitry, python programming, hardware configuration, etc., by doing workshops with the Bridge21 model to learn Raspberry Pi. Several states such as set up phase, warm-up, investigation stage, planning stage, create a stage, present, reflect those stages to do projects and learn with Raspberry Pi by J. R. Byrne et al. (2016). Peter Jamieson et al. (2016), Integrating Raspberry Pi into education thus enhancing the student's skills in Project-based learning for ECE students by introducing Pi related courses into curriculum against several challenges such as OpenSource project accessibility, student progress, etc. Marina et al. (2015) installed Remote Experimental Labs (RExLab) to teach various physics concepts in the schools using the Raspberry Pi B model and PiFace interface.

E. IoT and Raspberry Pi Technology:

Real-time emotion-based facial recognition system using Image processing techniques to detect facial emotions such as anger, disgust, happiness, surprise, and neutral with Raspberry Pi with CMU MultiPIE database with image collections. With remote desktop connections, Virtual Network Connections (VNC), and putty software by Suchitra et al. (2016), AI-based smart mirror-like interface device equipped with Raspberry Pi, microphone, speakers to display weather updates, news, etc., with speech recognition by Vaibhav et al. (2017). A speech-based robot connected to a Raspberry Pi board through Bluetooth or Wi-Fi, and further it is operated based on the commands with APP AMR Voice by Renuka (2017). Drones and raspberry pi technology are used to educate students on the robotics course by building their drones on the Robotics OS using any web and SSH environmentlike a base station. Equipping a single piece plastic frame, ESC driven DC motors along with reinforced shafts and bearers via JavaScript interfacing to SkyLine3, camera, and IR distance sensors by Isaiah et al. (2018). A wireless notice board displays text, image, or pdf files on Projector and mobile application to convert any voice message into text format and sent back to the board using cloud storage by Ganesh E.N. et al. (2018). 360-degree video processing with raspberry pi to improve teaching and learning experiences with AR/VR technology based on scenarios such as Teacher training video analysis, Mobile lecture recording, and Group discussions by Micheal et al. (2018). Investigation on the applicability of Raspberry Pi as an IoT technology in the field of education considerably in a teaching process along

with Learning Management System (LMS), Machine Learning, To examine student social behavior based on the facial expression with Face detection technology, Feature Extraction, Classification based on facial expression. Teachers' feedback on lecture quality by Salman et al. (2019). On some specific topics trending nowadays, few pieces of literature have been proposed, such as MichealDerntl et al. (2013) proposed a dynamic topic mining model to address various challenges in Learning Analytics and Knowledge (LAK) data sets and to explore and visually analyze D-VITA a web-based browsing tool was developed for dynamic topic models. Some other papers were related to IoT-based smart education systems as in 2018, N.Indira et al. developed a voice-controlled robot arm with Raspberry Pi using Google Alexa and Artificial Neural Network. Alberto Pacheco et al. (2018) tried creating an Osmotic computing architecture model for an IoT-based smart classroom used to test deep learning models for person detection by a comparative study with Cloud, fog microserver, and mobile edge computing devices against some limitations with real-time responses with IoT applications.The above analysis for subsections E. and F. is based on the references [127] - [168]. Furthermore, Articles related to the deployment of Intelligent Classroom infrastructure that were experimented since the last few decades have also been tabulated, combining along with Deep Learning based Intelligent Classroom experiences in the references from [169]- [204]. Finally, the above-accomplished data analysis has been given in table format below forthe author's reference.

DISCUSSION AND FINDINGS

The article reviews are under a wide range of topics and categories related to IoT, Raspberry Pi, and Computer Vision in Higher Educational Institutions. The keywords from the articles are as follows: Due to the unnatural time limit, merely 200 articles were considered for the review work. Articles available in Non- English languages have not been considered for this study. As the investigation was conducted only on Google Scholar, IEEE Xplore, International Conferences, and Journals, few academic databases were not included in thestudy. Looking into the review results, the rise of Raspberry Pi and Computer Vision in the Higher Education Sector can be visible from the past 20 years until the present. The IoT impacts on Higher Education are huge, driving education into a smart and intelligent educational environment. As we have seen, various works related to IoT based on higher educational development. Different literature works were collected and reviewed separately for Raspberry Pi applications in higher education and its application in higher education specific to Computer Vision Technology such as Augmented Reality, Virtual Reality, and 3D, Image Processing Technology Robotics. This study reveals that a huge set of examples are available in each corner of the higher education sector. Take these scenarios and choosing from the recent trending technologies. These systems have a greater scope of making a new educational transformation in the real-time future. Keeping this as the first step, we can explore and build more projects, products, and systems by integrating two or more technologies to form a highly potential education system. It is just a start in deriving new invaluable sights through more in-depth analysis of the enormous number of educational data using Data Mining and Analytics, Artificial Intelligence and Machine Learning Algorithms, Deep Learning Algorithms, Educational Data Mining (EDM), and Learning Analytics and Knowledge (LAK), Fog/Edge Computing, Osmotic Computing, Sensor Data Analytics, Predictive Analytics, Multimodal sensor data fusion, Fusion of Computer Vision and Natural Language Processing Systems such as Lip Reading Systems, Visual content retrieval, etc. Thus formed IoT generated big data can help form a more efficient, better operational, and automated intelligent educational infrastructure that can be deployed. The study reveals that only lesspapers are available on Real-time analytics, second highest with Artificial intelligence, Machine Learning, and IoT-based Classroom setup, and fewerpapers in Fog/Edge Computing, Simulation Environments, Robotics, Osmotic Computing, Sensor data analytics. Based on this investigation, further experimentation can be performed. The dimensionality of using Deep Learning inside the Embedded devices especially, IoT devices or mobile devices with low resource constraints, is possible by adhering to few configurations and adjusting to suit the framework (i.e., Light-weight neural networks / neural accelerators, etc.) to support the classroom use cases. Finally, this discusses and concludes that experiments on the intelligent classroom structures can improve the experiences of potential classroom environment through light-weight deep learning systems for dealing with Computer Vision applications on embedded devices such as IoT or

Mobile devices. Thus, it results in enhancing the performances of the educational workflows in the coming future."

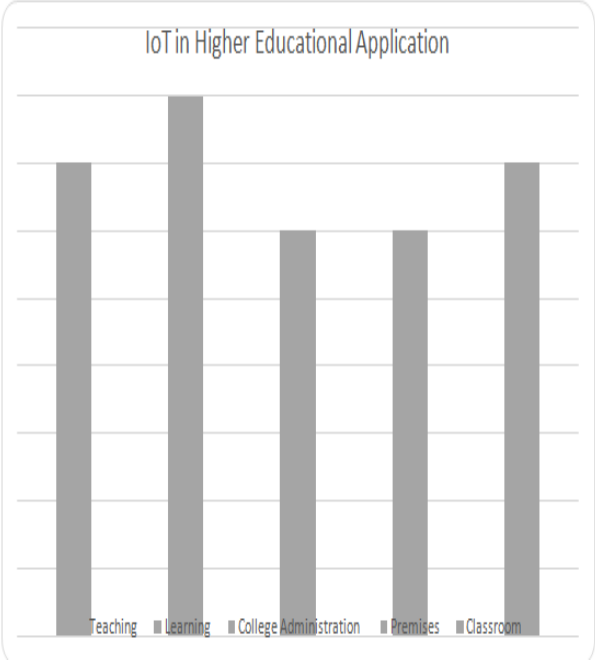

Figure 4. IoT in Higher Educational Application.

From the 34 articles selected on "IoT in Higher Educational Applications," 7 papers are related to Teaching, 8 papers are related to Learning, 6 are related to College Administration, 6 are related to College Premises, and 7 papers are related to Classroom implementation in a general keyword search on "IoT in Higher Education." The following figure (Fig 3.) defines more papers related to the student's learning outcomes. (Fig 4.) depicts that Out of 31 articles, papers were from 1989 to 2018, with the highest paper works collected from the publication year 2017. Out of 33 Articles, papers were ranging from the publication year 2011-2018, with the higher number of papers from 2015 related to possible IoT applications in higher education as in (Fig 5.), Fig 6. shows the recent advancements in this field, with more number of papers from Real-time analytics, second highest with Artificial intelligence, Machine Learning, and IoT based Classroom setup and less number of papers in Fog/Edge Computing, Simulation Environments, Robotics, Osmotic Computing, Sensor data analytics, etc.

In the recent trends, as in (Fig 7.) Deep Learning-based IoT systems have been researched and explored for their implementation in the education sector for a classroom setup also to enable intelligence for the better experiences inside the Classroom

Figure 4 shows of IoT's Higher Education Application is from the Research articles 34 published in Teaching related to 7 Papers, learning related are 8, College Administration related are 6, Premises related are 6, Classroom related are 7. This indicates that Research articles published related to IoT in Higher Educational Application deviation in the value but it overall there is a significant rise in no of Research articles published in the last decade.

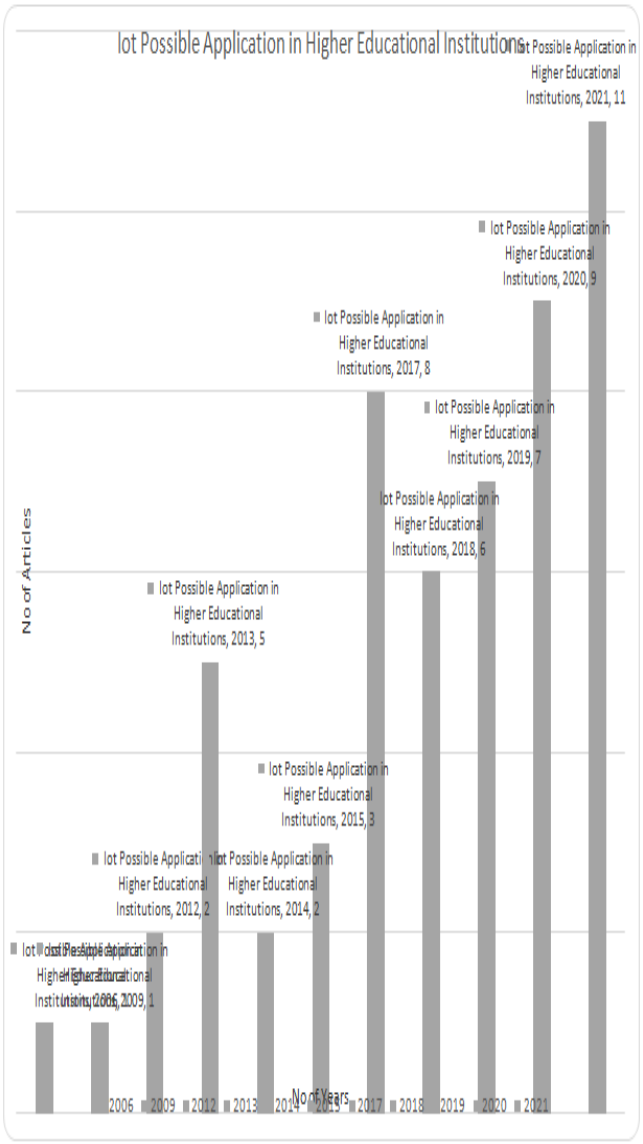

Figure 5. IoT Possible Application in Higher Educational Institutions.

Figure 5 showsIoT application in Higher Educational Institutionsis increasing from 2006 to 2021. No of Researcharticles published in 2006 in 1, whereas in 2021 it is reached to 11. This indicates that Research articles published related to

IoT application in Higher Educational Institutions is increased gradually from 2006 to 2021. Even though there is a slight deviation in the value but it overall there is a significant rise in no of Research articles published in the last decade.

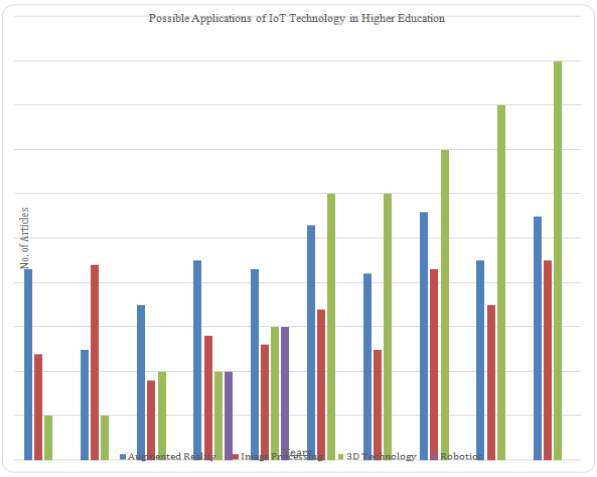

Figure 6. Applications of IoT Technology in Higher Education.

Figure 6 shows Applications of IoT Technology in Higher Education is increasing from 2008 to 2021 No of Research articles published in Augmented Reality 2008 in 4.5, whereas in 2021 it is reached to 5.5, Image processing 2008 in 2.5 whereas in 2021 it is reached to 4.5, 3D technology 2008 in 1 whereas in 2021 it is reached to 9, robotics 2015 in 2 whereas in 2016 it is reached to 3. This indicates that Research articles published related to IoT application of IoT Technology in Higher Education it increased gradually from 2008 to 2021. Even though there is a slight deviation in the value but it overall there is a significant rise in no of Research articles published in the last decade.

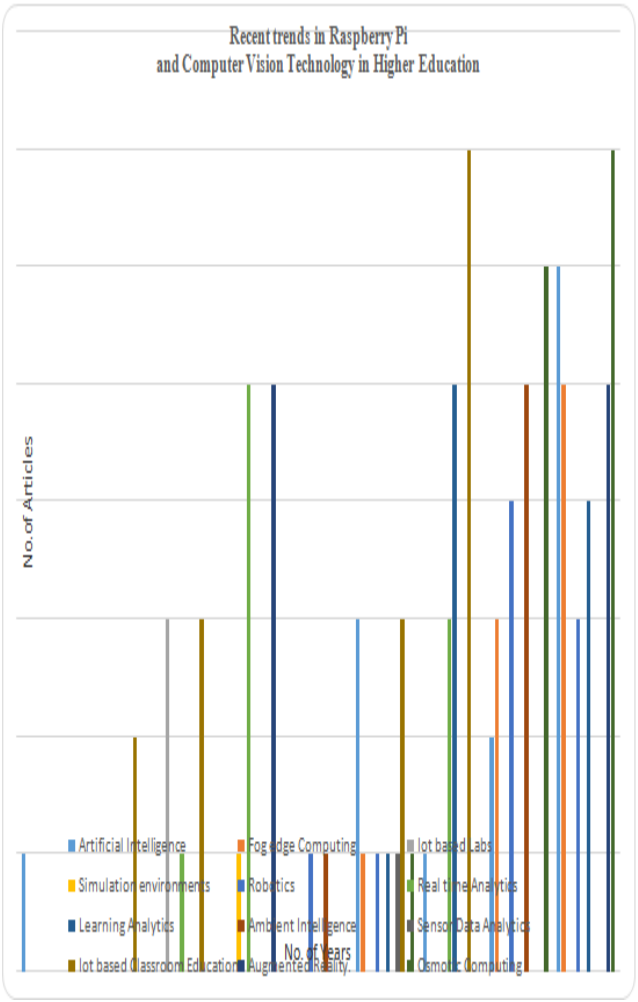

Figure 7. Recent trends in Raspberry Pi and Computer Vision Technology in Higher Education.

Figure 7 showsRecent trends in Raspberry Pi and Computer Vision Technology in Higher Education is increasing from2013 to 2021. No of Research articles published in 2013 in 1, Artificial Intelligence, Simulation environments, Learning Analytics, IoT based Classroom Education, Fog Edge Computing, Robotics, Ambient Intelligence, Augmented Reality, iot based labs, Real-time analytics, Sensor data Analytics, Osmotic Computing whereas in 2021 it is reached to 7. This indicates that Research articles published related to Recent trends in Raspberry Pi and Computer Vision Technology in Higher Education is increased gradually from 2013 to 2021 Even though there is a slight deviation in the value but it overall there is a significant rise in no of Research articles published in the last decade.

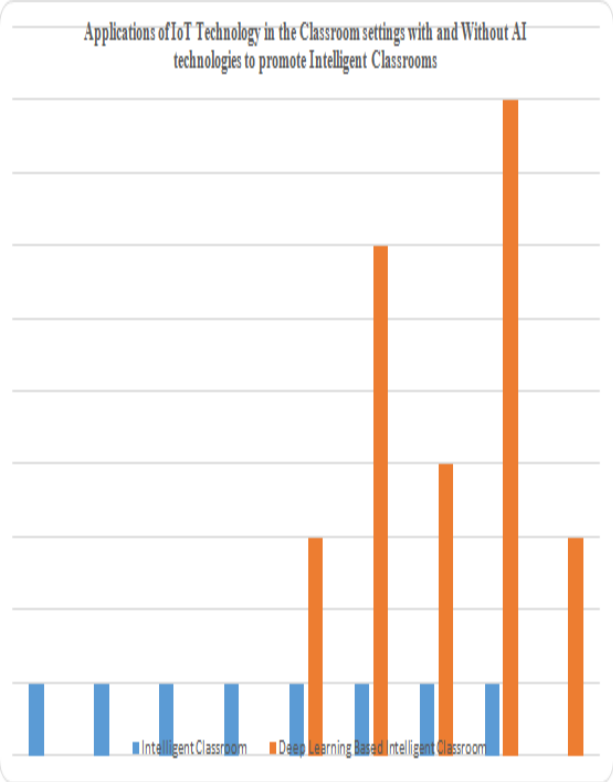

Figure 8. Applications of IoT Technology in the Classroom settings with and Without AI technologies to promote Intelligent Classrooms.

Figure 8 shows Applications of IoT Technology in the Classroom settings with and Without AI technologies to promote Intelligent.
is increasing from 2010 to 2021. No of Research articles published inIntelligent Classrooms 2010 in 1, whereas in 2020 it is reached to 1, Deep Learning based Intelligent Classroom 2017 in 3, whereas in 2020 reached to 9, 2021 in 3. This indicates that Research articles published related to Applications of IoT Technology in the Classroom settings with and Without AI technologies to promote Intelligent Classrooms is increased gradually 2010 to 2021 Even though there is a slight deviation in the value but it overall there is a significant rise in no of Research articles published in the last decade.

CONCLUSION

The vast technological demand in the Higher Educational Sectors makes these systems an optimal solution, thus their growth and the technological advancements have given rise to look for a solution, i.e., IoT Technology. It is familiar that IoT usage in educational history dates back to the nineteenth century. But its potential reformation in the past few decades has proven it to promote a promising future in the Higher Education Sectors' technological upliftment. Narrowing down IoT technology combined with Computer Vision techniques will create a broader view on how the surrounding environment is managed to evolve with the visual signs resulting in innovative use cases for the Higher Educationalfield.
Additionally, very few papers have been proposed from the teacher's perspective of an intelligent classroom environment. This paper surprisingly came across various new ten domains such as Learning Analytics and Knowledge (LAK), Educational Data Mining (EDM), Fog and Edge Computing, Osmotic Computing, Sensor Data Analytics, Predictive Analytics, Artificial Intelligence, Machine Learning,DeepLearningmodels, andSimulation environments with the trend set of forming the concept of invoking Automation and Intelligence in the HEI environments emphasizing on the importance on the field of analytics, mining techniques related to education, node-level computations, sensor level analytics ., etc. This review reveals that these state-of-the-art technologies and new trending technologies related to IoT and Computer Vision can help researchers, developers, and scientists based on this area of interest to promote automated intelligence in the HEIenvironment. This review paper leads us to further experiment with using these Deep Learning-based IoT systems to enable intelligent classroom environments for enhanced experiences in the future classroom models.
These summarized Raspberry Pi applications in forming a smart and intelligent educational infrastructure can be considered a starting guide for new ideas. This review paper limited to Computer Vision technology will help those interested in IoT-based Computer Vision system deployment. The future of IoT concept with Computer Vision seems to be more amusing as more connecting things will start to communicate with less human interaction bringing a shift in how higher education and its environment will thrive tosurvive.

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