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Voices

- IT Technical magazine is a platform for IT students to express their creativity and showcase their literary skills.
- VOICES is designed to present to its readers the technical developments and technical papers that have been prepared by IT students.

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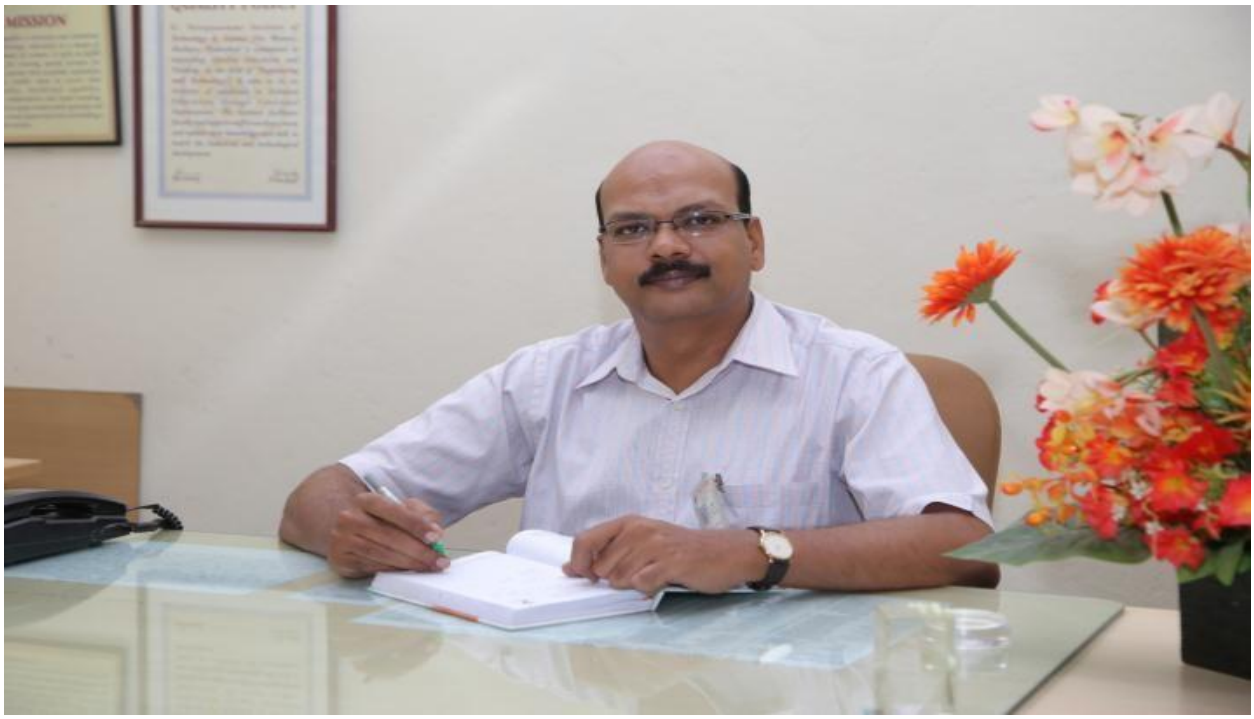

I feel very elated and at the same time privileged to share a few words as you go through the pages of the magazine "VOICES". IT department endeavors to help students to seek the best from the surroundings. The knowledge thus gained becomes a ladder for them to soar into greater heights. It's often the collective effort that leads to the discovery and fulfillment of aspirations.

I feel proud to be a part of VOICES an instrument in moulding the students. We try to shape every sphere of a student's personality in the IT Department. I take this opportunity to express my sincere thanks to all the members of the faculty and auxiliary staff for their sincere contribution in making this Edition.

Dr.I.Ravi Prakash Reddy
Professor & HOD

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Applications of Augmented Reality

Akula Manaswini **19251A1203** **IT-A(4/4)**

Augmented Reality is a combination of a real and a computer-generated or virtual world. It is achieved by augmenting computer-generated images on real world. It is of four types namely marker based, marker less, projection based and superimposition based augmented reality. It has many applications in the real world. AR is used in various fields such as medical, education, manufacturing, robotics and entertainment. Augmented reality comes under the field of mixed reality. It can be considered as an inverse reflection of Virtual Reality. They both have certain similarities and differences. This paper gives information about Augmented Reality and how it started. It analyses various types of augmented reality, its applications and its advantages and disadvantages. This paper also gives us knowledge regarding those major threats that augmented reality will face in the near future and about its current and future applications. It gives us a comparison between the two related topics, Augmented reality and Virtual reality. The following paper also helps us know about the effect of Augmented Reality on the human life.

There are four types of Augmented Reality (AR) observed namely,

Marker based AR

This type of reality is also known as Image Recognition . A camera and a visual marker such as a QR code or a 2D code is used. First the marker is sensed by the reader and then the output is given. Apps based on this type uses a camera to differentiate a marker from any other real world object. Markers can be anything which are unique yet simple (e.g. QR Code) and should be detectable by the camera. Calculations of position and orientation is done.

Marker less AR

This type of reality is also known as Location-based reality or GPS. Data which is provided is based on our location and is provided with the help of a digital compass, accelerometer, velocity meter or GPS. All these are inserted in our devices. This type of reality is possible because of the location detection features available on our smartphones these days. It recognizes things that were not directly provided to the application in

advance, unlike Marker Based AR. Here, the algorithm only has to identify the patterns, the colors, and the other features in order to provide results.

Projection Based AR

As the name suggests, artificial light is projected onto realworld objects. This allows for human interaction by sensing the touch of that projected light. User's touch is detected by distinguishing between an expected projection and an altered projection. A digital operating canvas is created on virtually any work surface. Projection based AR is used to project a 3D interactive hologram.

Superimposition Based AR

In this type of reality, the original view of an object is either partially or fully replaced with a newly augmented view of that same object . Here, object recognition plays an important role. E.g. IKEA - Augmented Reality Furniture catalogue. It is a virtual furniture app that augments furniture onto real floor.

ADVANTAGES

- AR can be used to increase the knowledge bars of people.
- AR's availability is improper in social situations. AR can help people share experiences over long distances.
- AR has a form of escapism
- A life-like experience can be established by AR games.

DISADVANTAGES

AR's availability is improper in social situations.

- There are no strong security features in this technology.
- AR has a feature of spam
- There are various issues like that of performance, alignment and interaction.

APPLICATIONS OF AUGMENTED REALITY

Medical : Augmented Reality will be far-reaching in the near future. It is being widely used in healthcare sector where there is a need of visualizing the medical information and the patient within the same physical space . Augmented Reality can be used to perform surgeries and can help surgeons perform real time surgeries

without being physically present near the patient . Some of the real life examples where AR is being used in medical field are

EyeDecide : This is a medical app which simulates the impact of specific conditions or medicines on a person's vision using a camera. E.g. EyeDecide can demonstrate the impact of cataract.

AccuVein : This app uses a handheld camera which projects over the skin. Thus nurses and doctors get to know where the veins are in the patients' bodies.

Entertainment and Games Augmented Reality can be proved to be a game-changer for entertainment and games. Here, it is possible to interact with the real world and reel world using this technology. AR can be used in Television Broadcasting. Many sports channels use AR thus allowing audience to view graphic overlays . AR is widely used in Gaming too. Apps such as Ingress and Pokémon Go use augmented reality to let gamers play with virtual characters in real world.

Robotics : In this field, AR makes it easier for robots for communicating complex information to humans. Moreover, this technology can help robots perform surgeries by combining AR with surgical robot system for performing head surgeries. In a nutshell, AR is a platform that has made human-robot collaboration possibleManufacturing Augmented reality has helped in improving the understanding of the product assembly tasks to be carried out. Information overload and the training required for assembly operation can be reduced using the AR approach. In manufacturing, AR can help in complex assembly of machinery, in maintenance of parts and in providing expert support.

Education : Augmented reality in education has been proved to be very fruitful. The young learners can now visualize complex spatial relationships [7] and abstract concepts. This technology helps students to engage in phenomena that are not possible in real world. Moreover, the invisible concepts [7] like magnetic field can now be visualized easily using AR. Augmented Reality can open additional ways and methods of making the learning process easier and interesting.

IoT(Internet of Things)

Shaik Sadaf Tabassum **20251A12B8** **IT-B(3/4)**

We are entering in a beginning of a new of computing technology i.e. Internet of Things (IOT). IOT is a sort of “universal global neural network” in the cloud which connects various devices. The IOT is an intelligently connected devices and systems which be made up of smart machines interacting and communicating with other machines, environments, objects and infrastructures and the Radio Frequency Identification (RFID) and sensor network technologies will go up to meet this new challenge. As a result, a very large in size data are being generated, stored, and that data is being processed into useful actions that can “command and control” the things or devices to make our lives much easier and safer—and to reduce our influence on the environment. This paper gives an overview of Internet of Things (IOT) and brief information about IOT applications and challenges in various fields.

The phrase "Internet of Things" was invent by Kevin Ashton in 1999. He made at his place of employment, Proctor & Gamble. During his time there, Ashton came up with the idea of putting a RFID tag on each lipstick and having them communicate with a radio receiver. He put forward as fact that such data collection can be used to solve lots of problems in the real world. At the moment, a lot of connected devices can talk to internet and to our smart phones, and maybe even some similar products, but most of them can't talk to one another because of branded hardware and software with differing standards, languages and communication protocols. For most of the current smart household items, you'll need to use a different app or website to interface with the device. Unless they were especially designed by the manufacturer to work together. K. Rose in 2015 gave reasons that why IOT is possible. He said it is possible due to following reasons: Ubiquitous Connectivity, widespread adoption of IP– based networking, computing economics, advances in Data Analytics, rise of Cloud Computing so, the IOT is the conjunction of a variety of computing and connectivity trends that have been evolving for many decades.

APPLICATION OF IOT IN DIFFERENT FIELDS

- IOT in industry: Indoor Air Quality: Monitoring of oxygen levels and toxic gas inside chemical plants to ensure workers and goods safety. Monitor the temperature inside the industry. In food factories monitoring of ozone levels during the drying meat process. Information collection from Can Bus to send real time alarms to emergencies or provide advice to drivers.
- IOT for Smart Home: IOT that turns the automated home into the smart home. With a combination of sensors, smart systems, IOT connects everyday objects to a network, enabling those objects to complete tasks and communicate with each other, with no human input. This in turn the home automation, connected devices and IOT you get a Smart Home. And a modern smart home can be easily controlled through a smart phone, tablet or computer.
- IOT for Agricultural Production: Implementing IOT in agricultural field for developing the supply and growth of the crop by collecting the information from the environment sensor. The need of agricultural products could be predicted measurably, but due to the slight difference in condition of harvest and weather change, disease and insect damage etc. could not be predicted, so that the supply and need of agricultural products has not been controlled properly. To overcome it, the IOTbased monitoring system to analyze crop environment and the method to improve the efficiency of decision making by analyzing harvest statistics.
- IOT for Health Care: IOT in the healthcare application is used to observe and check the progress the health condition of patient in one end from other end of the spectrum; especially it is more useful for patient in the remote location. IOT Healthcare solutions can remotely monitor patients be affected from various disorders like diabetes, dementia, Alzheimer etc., These applications will not only improve the access to care while increasing the quality of care but also reduce the cost of care.
- IOT in Transportation: IOT less in amount traffic congestion in the city. GPS and time information from city buses is displaying a city-wide view of the public transport system, with the action of predicting something of bus arrivals, transit times and route congestion on a digital map of the city. Based on this information, the city can take designed to correct the action to reduce traffic congestion and keep city buses running smoothly.

CHALLENGING AREAS

Security: There is a lot of chances of malware entering into the IOT network because it connects a lot of devices in the network. In case of less intended to protect someone where the devices are also less expensive are a subject to make unauthorized alterations. The integration of middleware, APIs, machine-to machine communication, etc. produce a lot of complexity and new security risks.

Trust and Privacy: With remote sensors and the action of watching a core use case for the IOT, there'll be heightened sensitivity to dominant access and possession of knowledge. The action can still be a significant issue in medical and assisted-living applications, which might have life and death unwelcome consequence of an action. New compliance frameworks to deal with the IOT's serving to distinguish it from others problems can evolve. Social and political issues during this space may make it difficult IOT adoption.

- Complexity, confusion and integration problems: With multiple platforms, various protocols and huge numbers of arthropod genus, IOT systems integration and testing are challenges refer to briefly the smallest amount. The uncertainty about what is happening around evolving standards is nearly bound to slow adoption. The fast evolution of arthropod genus can probably consume out of the blue development resources that may diminish project teams' talents to feature core new practicability.
- Evolving architectures, protocol wars and competitive standards: With such a large amount of players attached the IOT, there are sure to be in progress an area wars as a legacy corporations ask for to shield their proprietary systems blessings and open systems proponents try and set new standards.
- . Concrete use cases and compelling worth propositions: Lack of clear use cases can cut down adoption of the IOT through technical specifications, theoretical uses and future ideas might serve for a few early adopters, thought adoption of IOT would force reasoned, customer-oriented communications and electronic communication around "what's in it on behalf of me."

Through IOT, each and every object in this world can be identified, connected and take decisions independently. In the near future the Internet and wireless technologies will connect different sources of information such as sensors, mobile phones and cars in an ever tighter manner. The number of devices which connect to the Internet is – seemingly exponentially – increasing.

Application of AI/Machine Learning

Nandula Vyjayanthi **21251A3649** **CST(2/4)**

Machine Learning (ML) and Artificial Intelligence (AI) techniques learn models or inference rules from data. Classification, clustering, rule based systems, etc., are some sub categories which learn the latent knowledge of the domain using training data. In early days limitations in data availability and computing power made them to use only for simpler tasks. Recent advances in robust algorithms combined with huge data publicly available and increase in computing power created more successful applications making ML/AI techniques very popular. Presently, ML/AI techniques are being used in all fields. In this paper, we are going to present few selected papers in which ML/AI techniques are successfully applied.

Data exploratory techniques like PCA and sparse representations are discussed in Signal and Data Processing applications. Section on Human Computer Interaction system explains in detail about OCR for printed and handwritten data of Indic script, Document Image segmentation techniques and text detection in images. Computer system section discusses in detail about performance of cache, schedulers in system performance subsection and about intrusion detection, trust models and replica selection in the subsection system security. Finally, few different applications using Neural Network are discussed in the section applications of Neural Networks.

APPLICATIONS TO HUMAN COMPUTER INTERACTION

Another important application to ML/AI is Human Computer Interaction systems. Here variety of applications are built like Optical Character Recognition (OCR) for printed and handwriting, documents preprocessing, etc. In following sections we will discuss few popular applications.

Printed Recognition Classical OCR problem converts text in images or scanned documents into editable text format. The complete OCR system has several steps like data preprocessing, segmentation and then recognition. OCR problem is a well studied problem in literature. Here, we present work done on one of the Indic scripts, Telugu. Telugu is a South Indian language with more than 100 million speakers. Authors used glyphs (connected components) as basic recognition units. They used fringe maps to represent the glyphs and performed template matching for classification. Different factors in segmentation and recognition stage

that affect the system performance are discussed in detail. A complete system for printed Telugu OCR is first presented .Authors in this paper proposed novel techniques for handling broken characters and poor segmentation. For broken characters they are identifying the abnormal Connected Components (CC) by matching them with the templates in database and merging with the nearest CC.

If the merged CC is normal then it is stored otherwise it is not stored. The authors also proposed segmentation based on orthographic properties of Telugu script. Binarization of images also affect the system performance.

HANDWRITTEN CHARACTER RECOGNITION

Handwritten character recognition is an extension to printed character recognition. Models built for handwritten character recognition fail to work with handwritten data due to high intra-class variance present in the data. Differences in writing styles of the writers increases the intra-class variance making this problem interesting and more challenging. Authors worked on basic Telugu handwritten characters. They generated sequence numbers for handwritten characters and stored them in tries, which they call as 'sequence tries'. Sequence tries are generated for all templates and now the classification is simply reduced to string matching. For classifying test samples, all that is required is to generate sequence tries and perform string comparison with stored sequence tries.

IDENTIFICATION OF TEXT IN IMAGES

Another important application of ML is identifying text in images. It is different from classical OCR problems as the images contain graphics along with text and layouts also differ. Recognition part may be same but the difficulty lies in text segmentation. One such efficient system for text identification can be seen .Here first Sobel gradient magnitudes for image are found and then Hough transforms are applied to get text regions. Since Telugu script is circular in nature, Hough transforms for circles are used to locate text. Recursive XY cut approach is used on located regions to segment into regions of paragraphs, lines and words. A bottom up approach is employed to extract words from located regions. Zoning is done using a 4 × 4 grid on locally binarized words to identify glyphs. Cavity filling is done after analysis of glyphs to generate structural feature vectors. Finally template matching is used for classification of glyphs.

APPLICATIONS OF ML TO COMPUTER SYSTEMS

System Performance

ML can be used to optimize resource utilization leading to system improvement. Generally, in process scheduling, systems consider the time constraint. Using a ML framework which reduces the total turnaround time of the processor. Authors used C4.5 algorithms to predict the important static and dynamic attributes of the programs. Based on these predicted attributes, customized time slices are used in scheduling. This framework reduced the total number of context switches resulting in reduced turnaround time

System Security

Intrusion Detection: Intrusion detection is widely studied problem using ML techniques. In general, intruders are hard to find due to their malicious behavior. Using ML techniques, we can learn models on normal user profiles and some known intruder profiles and this model can be used for intruder detection.
Masquerade: detection is also another kind of intrusion detection, but one user will be assuming to act as another one.

In this paper, a wide range of systems is revised. These are all based on the works of the first author and his associates. It shows how AI and ML methods are ubiquitous and widespread in their applications to computer systems.

Review on Augumented Reality

T.Laxmi Sowgandhika **19251A12B5** **IT-B(4/4)**

Augmented reality has come a long way from a science-fiction concept to a science-based reality. Until recently the costs of augmented reality were so substantial that designers could only dream of working on design projects that involved it today things have changed and augmented reality is even available on the mobile handset. That means design for augmented reality is now an option for all shapes and sizes of UX designers.

Augmented reality is a view of the real, physical world in which elements are enhanced by computer-generated input. These inputs may range from sound to video, to graphics to GPS overlays and more. The first conception of augmented reality occurred in a novel by Frank L Baum written in 1901 in which a set of electronic glasses mapped data onto people; it was called a "character marker". Today, augmented reality is a real thing and not a science-fiction concept.

Nowadays, one of the technologies that shows great potential in education especially in visualizing abstract concepts is AR. According to Martin et al. (2011), AR is a new technology that is likely to have an impact on education. This claim is supported by the Horizon Reports from 2004 to 2010 which describe AR as a technology that brings the computer world to the human world (Madden, 2011). AR is different from virtual reality because AR combines the real world with computer graphics, while virtual reality immerses the user in a computer-generated world. AR is a new way to improve the learning of three-dimensional shapes instead of the traditional method in which teachers use wooden objects. According to Cerqueira and Kirner (2012), there are several advantages of using AR techniques for educational purposes. For example, AR can minimize the misconceptions that arise due to the inability of students to visualize concepts such as chemical bonds, because AR allows detailed visualization and object animation. AR also has the advantage of allowing macro or micro visualization of objects and concepts that cannot be seen with the naked eye. AR displays objects and concepts in different ways and at different viewing angles which helps the students to better understand the subjects (Cerqueira & Kirner, 2012). In addition, most of the research conducted on AR to date shows that students are excited and interested to learn using this technology.

For example, in research conducted by Klopfer and Squire (2008), students gave positive feedback about their experience of the combination of the virtual and real environments. Burton et al. (2011) also reported a similar result, with the participants in their study clearly excited about the potential of this technology for sharing information and learning about new concepts. This feedback is useful in determining the readiness of students to accept and use this new technology. AR also makes students become more active in the learning process due to the interactivity of its applications (Lamounier et al., 2010). Thus, it encourages students to think critically and creatively which, in turn, improves their experiences and understanding.

Augmented reality is achieved through a variety of technological innovations; these can be implemented on their own or in conjunction with each other to create augmented reality. They include:

General hardware components – the processor, the display, the sensors and input devices. Typically a smartphone contains a processor, a display, accelerometers, GPS, camera, microphone etc. and contains all the hardware required to be an AR device.

Displays – while a monitor is perfectly capable of displaying AR data there are other systems such as optical projection systems, head-mounted displays, eyeglasses, contact lenses, the HUD (heads up display), virtual retinal displays, EyeTap (a device which changes the rays of light captured from the environment and substitutes them with computer generated ones),Spatial Augmented Reality (SAR – which uses ordinary projection techniques as a substitute for a display of any kind) and handheld displays.

Sensors and input devices include – GPS, gyroscopes, accelerometers, compasses, RFID, wireless sensors, touch recognition, speech recognition, eye tracking and peripherals.

Software – the majority of development for AR will be in developing further software to take advantage of the hardware capabilities. There is already an Augmented Reality Markup Language (ARML) which is being used to standardize XML grammar for virtual reality. There are several software development kits (SDK) which also offer simple environments for AR development.

There are apps available for or being researched for AR in nearly every industrial sector including:

Archaeology, Art, Architecture
Commerce, Office
Construction, Industrial Design
Education, Translation
Emergency Management, Disaster Recovery, Medical and Search and Rescue
Games, Sports, Entertainment, Tourism
Military

This review of the research conducted in several fields in education shows that AR technology has the potential to be further developed in education. This is because the advantages and beneficial uses of AR features are able to engage students in learning processes and help improve their visualization skills. The features can also help teachers to explain well and make the students easily understand what they are taught. The use of AR technology has also received positive feedback from participants and students who have shown their interest in using AR in their learning processes. These good responses are important because they indicate the willingness of students to actively engage in their studies through AR tools. AR technology is still new in education, thus there are still some limitations. However, the review of the research indicates that most of the limitations are related to technical issues. Such limitations can be overcome over time as research on the integration of AR in education is replicated and improved. When the potential of AR technologies is more fully explored, the beneficial functions of AR can begin to be used widely in all fields of education and the efficiency of the teaching and learning process will be improved.

Introduction to IoT(Internet of Things)

D.Manvita Krovvidi **20251A3637** **CST(3/4)**

The rapid development and implementation of smart and IoT (Internet of Things) based technologies have allowed for various possibilities in technological advancements for different aspects of life. The main goal of IoT technologies is to simplify processes in different fields, to ensure a better efficiency of systems (technologies or specific processes) and finally to improve life quality. Sustainability has become a key issue for population where the dynamic development of IoT technologies is bringing different useful benefits, but this fast development must be carefully monitored and evaluated from an environmental point of view to limit the presence of harmful impacts and ensure the smart utilization of limited global resources. Significant research efforts are needed in the previous sense to carefully investigate the pros and cons of IoT technologies. This review editorial is partially directed on the research contributions presented at the 4th International Conference on Smart and Sustainable Technologies held in Split and Bol, Croatia, in 2019 (SpliTech 2019) as well as on recent findings from literature. The SpliTech2019 conference was a valuable event that successfully linked different engineering professions, industrial experts and finally researchers from academia. The focus of the conference was directed towards key conference tracks such as Smart City, Energy/Environment, e-Health and Engineering Modelling. The research presented and discussed at the SpliTech2019 conference helped to understand the complex and intertwined effects of IoT technologies on societies and their potential effects on sustainability in general. Various application areas of IoT technologies were discussed as well as the progress made. Four main topical areas were discussed in the herein editorial, i.e. latest advancements in the further fields: (i) IoT technologies in Sustainable Energy and Environment, (ii) IoT enabled Smart City, (iii) E-health – Ambient assisted living systems (iv) IoT technologies in Transportation and Low Carbon Products. The main outcomes of the review introductory article contributed to the better understanding of current technological progress in IoT application areas as well as the environmental implications linked with the increased application of IoT products.

Keywords: IoT, Smart city, Sustainability, Energy, Environment, SpliTech2020

Several important facts need to be emphasized when addressing IoT technologies to be able to understand the long-term effects associated with the fast development of IoT

- IoT technologies have caused an increase in the utilization of limited resources or raw materials where some of them have become rare or are already rare (for instance, specific precious metals for electronics),
- The prices of electronic devices have become more acceptable, which means an increase in production volume, finally more resources are being utilized. A rebound effect is possible in that sense
- The long term environmental impacts of IoT technologies are unknown. A noticeable amount of energy would be needed to support the production and operation of IoT devices,
- An increase in electronic waste is expected due to the large estimated number of IoT based devices in the near future,
- In some sectors, IoT technologies could have social impacts due to the reduced necessity for labour and limitation of direct social contacts, which is vital and an important aspect for each human being.

Necessity for smart technologies The necessity for IoT technologies is closely linked with ongoing technological advancements and digitalization where a variety of different electronic products need to be somehow connected in a useful manner. There is a necessity for more efficient services and flexible processes in general, which could be obtained with the proper implementation of IoT technologies. IoT technologies have allowed for a variety of efficient services and smart networking, applications or devices that can ensure useful synergic effects and produce benefits. The major advantage of IoT technologies is their connectivity aspect that has enormous potential, Various benefits are possible and would be gradually integrated in our lives thorough upcoming years in different application areas and will be briefly discussed in the upcoming section of the introductory review editorial.

Application areas

- The transportation
- smart energy management in buildings
- or management of power networks,
- as well as the agriculture sector are also promising, having significant potential.

Review on AI/Machine Learning

P.Sravanthi **21251A12C0** **IT-B(2/4)**

Machine learning (ML) and artificial intelligence (AI) are becoming dominant problem-solving techniques in many areas of research and industry, not least because of the recent successes of deep learning (DL). However, the equation AI=ML=DL, as recently suggested in the news, blogs, and media, falls too short. These fields share the same fundamental hypotheses: computation is a useful way to model intelligent behavior in machines. What kind of computation and how to program it? This is not the right question. Computation neither rules out search, logical, and probabilistic techniques, nor (deep) (un)supervised and reinforcement learning methods, among others, as computational models do include all of them. They complement each other, and the next breakthrough lies not only in pushing each of them but also in combining them. Big Data is no fad. The world is growing at an exponential rate and so is the size of the data collected across the globe. Data is becoming more meaningful and contextually relevant, breaking new grounds for machine learning (ML), in particular for deep learning (DL) and artificial intelligence (AI), moving them out of research labs into production The problem has shifted from collecting massive amounts of data to understanding it turning it into knowledge, conclusions, and actions. Multiple research disciplines, from cognitive sciences to biology, finance, physics, and social sciences, as well as many companies believe that data-driven and "intelligent" solutions are necessary to solve many of their key problems. High-throughput genomic and proteomic experiments can be used to enable personalized medicine. Large data sets of search queries can be used to improve information retrieval. Historical climate data can be used to understand global warming and to better predict weather. Large amounts of sensor readings and hyperspectral images of plants can be used to identify drought conditions and to gain insights into when and how stress impacts plant growth and development and in turn how to counterattack the problem of world hunger. Game data can turn pixels into actions within video games, while observational data can help enable robots to understand complex and unstructured environments and to learn manipulation skills.

AI is "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."

This is fairly generic and includes multiple tasks such as abstractly reasoning and generalizing about the world, solving puzzles, planning how to achieve goals, moving around in the world, recognizing objects and sounds, speaking, translating, performing social or business transactions, creative work (e.g., creating art or poetry), and controlling robots. Moreover, the behavior of a machine is not just the outcome of the program, it is also affected by its "body" and the enviroment it is physically embedded in. To keep it simple, however, if you can write a very clever program that has, say, human-like behavior, it can be AI. But unless it automatically learns from data, it is not ML:

So, AI and ML are both about constructing intelligent computer programs, and DL, being an instance of ML, is no exception. Deep learning which has achieved remarkable gains in many domains spanning from object recognition, speech recognition, and control, can be viewed as constructing computer programs, namely programming layers of abstraction in a differentiable way using reusable structures such as convolution, pooling, auto encoders, variational inference networks, and so on.

There is a symmetric difference between AI and ML, and intelligent behavior in machines is a joint quest, with many vast and fascinating open research problems:

• How can computers reason about and learn with complex data such as multimodal data, graphs, and uncertain databases?

• How can preexisting knowledge be exploited?

• How can we ensure that learning machines fulfill given constraints and provide certain guarantees? • How can computers autonomously decide the best representation for the data at hand?

• How do we orchestrate different algorithms, involving learned or not learned ones?

• How do we democratize ML and AI?

• Can learned results be physically plausible or easily understood by us?

• How do we make computers learn with us in the loop?

• How do we make computers learn with less help and data provided by us?

• Can they autonomously decide the best constraints and algorithms for a task at hand?

• How do we make computers learn as much about the world, in a rapid, flexible, and explainable manner, as humans?

Fully programmed computations, together with learning-based programmed computations, will help to better generalize, beyond the specific data that we have seen, whether a new pronunciation of a word or an image will significantly differ from those we have seen before. They allow us to go significantly beyond supervised learning, towards incidential and unsupervised learning, which does not depend so much on labeled training data.

They provide a common ground for continuous, deep, and symbolic manipulations. They allow us to derive insights from cognitive science and other disciplines for ML and AI. They allow us to focus more on acquiring common sense knowledge and scientific reasoning, while also providing a clear path for democratizing ML-AI technology.

Machine learning and AI complement each other, and the next breakthrough lies not only in pushing each of them but also in combining them. Our algorithms should support (re)trainable, (re)composable models of computation and facilitate reasoning and interaction with respect to these models at the right level of abstraction. Multiple disciplines and research areas need to collaborate to drive these breakthroughs. Using computation as the common language has the potential for progressing learning concepts and inferring information that is both easy and difficult for humans to acquire.