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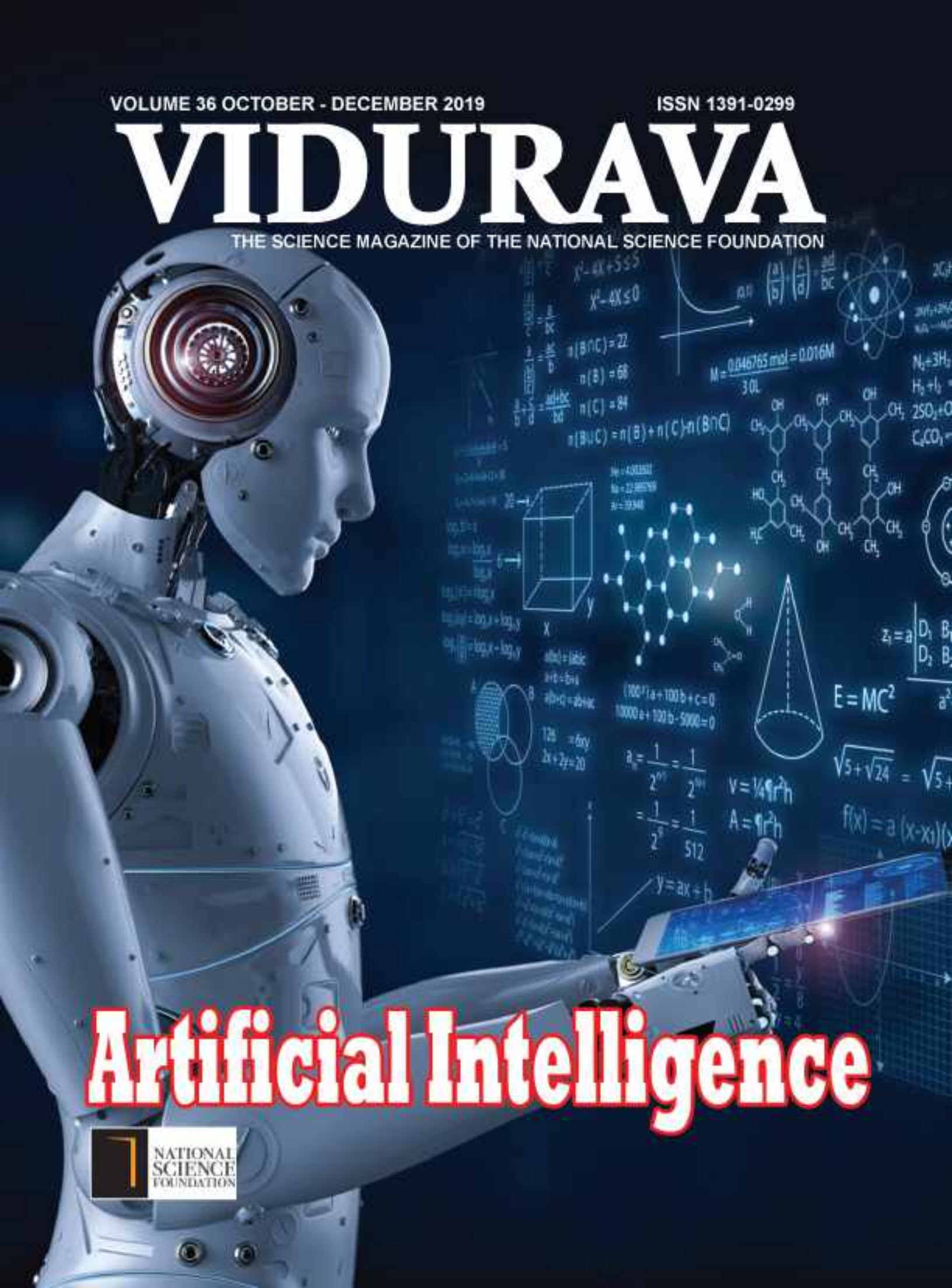

Artificial Intelligence

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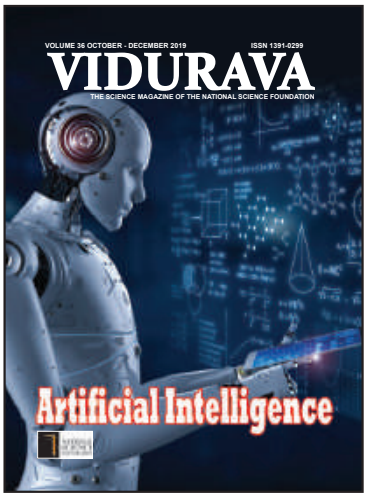

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Editorial

Beyond the Realm of Scientific Discovery

Artificial Intelligence (AI) in its simplest form, has been claimed by some authorities as the theory and development of computer systems capable of performing tasks that usually require human intelligence, such as visual perception, speech recognition, decision making and translation between languages.

Artificial Intelligence being the theme for the current issue of the Vidurava Science Magazine, has been reviewed from different angles in four illuminating articles. Apparently its initial entry to the scientific foray was its great utility value in military operations and intelligence activities, and in particular for surveillance exercises using what were identified as Unmanned Aerial Vehicles (UAV).

Subsequently, its uses in humanitarian causes such as surveillance of disaster affected situations as well as in assessing damage caused by natural or man-made disasters, appear to have generated substantial interest in its further advancement. But its entry into agricultural development activities, provision of emergency health services, contribution and participation in the Smart City concept as well as in technology and industrial development, are now expected to revolutionize lifestyles, work norms and more importantly to adoption and adaptation.

Science and scientific advancement in its very earliest and initial phases had been described as an extension of geographical exploration, and included the appraisal of natural resources as well as efforts in unraveling the basis of natural phenomena. Nevertheless, the current developments in AI are beyond the realm of such scientific discoveries, and as pointed out by one author, AI has been recognized as the fuel for the fourth industrial revolution. In addition, a futuristic predicament with what has been defined as Artificial Super Intelligence (ASI), is that if and when AI becomes more capable than human beings, it will out-perform human capabilities.

However, as a concluding anticlimax, let us ponder over what Ananda Kentish Coomaraswamy had to say about machines and machine operators in his mercurial treatise, *"Mediaeval Sinhalese Art"*, published in 1908.

European machines and machine-like men has in the East driven the village weaver from his loom; the craftsmen from his tools; the ploughman from his songs; and has divorced art from labour------. The craft is for him destroyed as a means of culture, and the community has lost one more man's intelligence, for it is obviously futile to attempt to build up by evening classes and free libraries, what the whole of a man's work is forever breaking down.

It is essential then for a re-union of art with labour, that machinery should be controlled ---- The place of machinery in a true civilization will be that of a hewer of wood, a drawer of water, a servant not a master -------- !

M. Asoka T. De Silva

Evolution of Artificial Intelligence

Prof. Asoka Karunananda

Introduction

Concept of intelligent machines is as old as abacus. Invention of a digital computer in 1950's, has reshaped the building of intelligent machines as a software exercise. In 1956, at the famous conference at Dartmouth USA, Professor John McCarthy coined the name Artificial Intelligence (AI) as the subject area of science and engineering of building intelligent machines. Thus, AI has two broad goals: **a**) scientific goal – understanding of intelligence of human, animals and machines; and **b**) development of intelligent machines. At this point it should be emphasized that Artificial Intelligence is about modelling of natural intelligence into machines. In other words, AI does not talk of an artificial form of intelligence. Birth of AI made a breakthrough in mankind. AI has recorded an unprecedented development over the last 65 years. The developments in AI has also immensely contributed to accelerate the research and development process in many areas including medicine, engineering, business, science, etc. Undisputedly AI has offered smart solutions for complex engineering designs, sophisticated medical diagnosis, forecasting in an unpredictable business environment, and simulations in large scale expensive and hazardous research. AI has shown its power to solve complex real-world problems that could not be solved by conventional techniques.

In the modern world AI has been recognized as the fuel for the fourth industrial revolution. Modern developments in AI promote man-machine coexistence, where the gap between man and the machines will be drastically reduced day by day. As such we are heading to an era of machines with biological organs/brains and humans with AI chips. Further, AI will be the most influential candidate of technological singularity where technology will be developed to a level at which machines surpasses mankind. Many researchers believe that singularity is coming soon. However, since AI promotes man-machine coexistence, the singularity by AI will not be harmful to mankind. This article presents how AI could be understood in a simple manner as gestation of AI; foundation of AI; developments in AI; and future of AI.

Rest of the article is organized as follows. Section 2 gives material for understanding AI in a simple manner. Section 3 is on gestation of AI, while section 4 presents foundation of AI. Major developments in AI are discussed in section 5. Section 6 is about Four schools of thoughts, which reports on different views of AI. Section 6 outlines future trends in AI.

2. AI made simple

The roadmap of AI records not only a heap of exciting developments, but also has loads of misconceptions and criticisms. Such criticisms have arisen due to attempts of some people to make AI difficult and so complex to the society. In fact, until the mid-1980s, development of AI happened to be invisible and secretive. This resulted in making people skeptical about AI. Consequently, it is essential to help the society to understand the true picture of AI.

Let us see how we can make the understanding of AI simple. In doing so, the behavior of the brain can be taken as the best inspiration to understand the

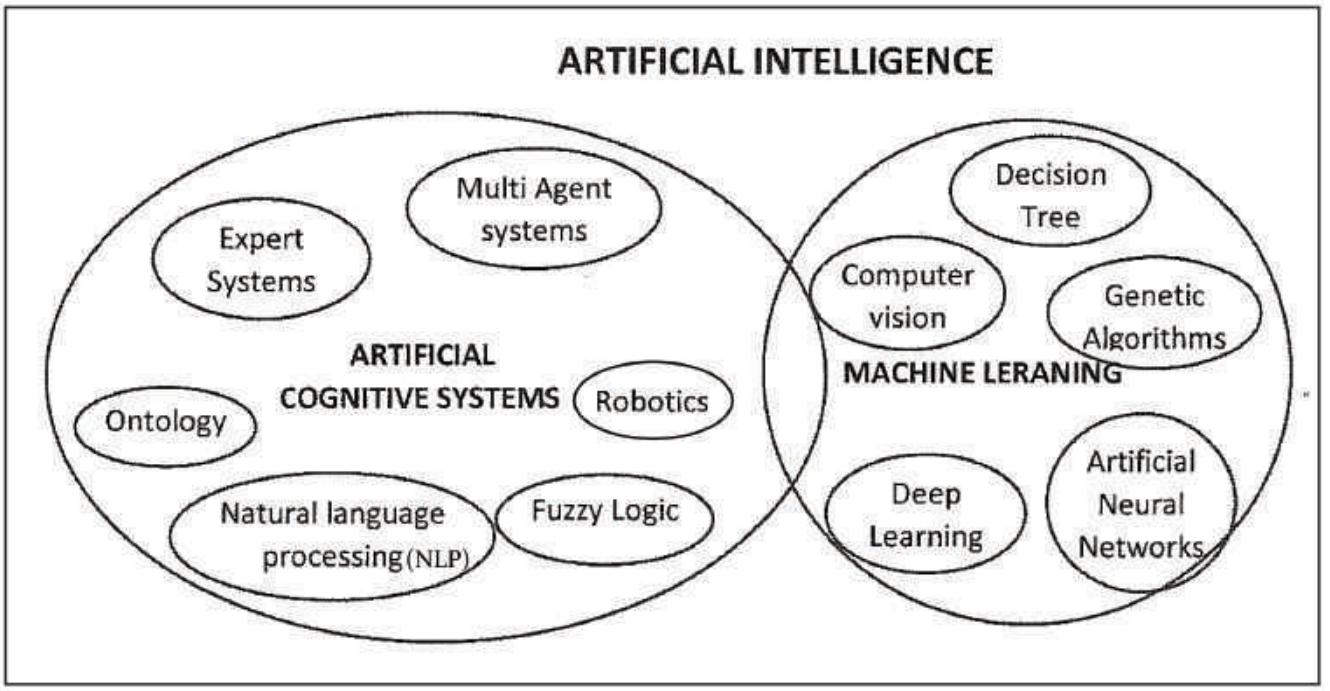

Fig 01 : Classification of some AI technologies

foundation of AI. According to neuroscience, brain manifests two forms of intelligence. One form of intelligence is associated with analytical/logical reasoning in the brain, while the other form is generated by training. These two forms of intelligence postulate two broad areas of AI as cognitive systems and machine learning respectively. These two phenomena are evident from the way a child prepares for an examination by learning theories in a logical manner and training to solve problems by doing past papers. Intelligence required for tasks such as music, driving, and swimming are largely based on training. In contrast, mathematical problem solving, engineering designs, scientific justifications require analytical/ logical reasoning of intelligence.

In general, intelligence with animals have largely emerged by training. For example, many animals such as dogs, horses, elephants and cats can be trained to do various things. There are also instances, where some animals show their analytical thinking as well. For example, when a cat is aiming at a rat, we have noticed the extent of strategic planning by the cat to reach the rat. We also notice, in some instances, a little rat also demonstrates its thinking ability to escape from the cat. Human beings claim that they are the most intelligent species of animals, by virtue of their power of analytical and logical reasoning. Nevertheless, we should not forget that cats are more competent than humans when catching a rat at home. Generally, both humans and animals have certain level of intelligence related to analytical/ logical reasoning and training.

Obviously, cognitive systems and machine learning approaches to intelligence are mutually beneficial to each other. For example, by knowing the theory of music, one can be trained faster to play music. Any AI technique including Expert systems, Artificial Neural Networks, Genetic Algorithms, Multi Agent Systems, Natural Language Processing (NLP), Computer Vision and Robotics could be classified under one or both of cognitive systems and machine learning. For instance, Artificial Neural Networks, Genetic Algorithms, and Decision Trees are recognized as machine learning techniques, while others come under cognitive systems. However, some AI techniques such as NLP, Robotics and Computer Visions can be considered under both artificial cognitive systems and machine learning. This is because, for example, we can process a language by learning grammar (theory) and by training or practicing a language. Figure 1 shows classification of some AI techniques under cognitive systems and machine learning.

3. Gestation of AI

Ending of the second world war in 1945 made people enthusiastic

in new discovery and inventions. In 1950, Allen Turing's seminal paper, Computing Machinery and Intelligence, also stimulated the idea of intelligent machines. Further, in 1948, the invention of the transistor marked the birth of modern digital computer, which deserves the credit for all kinds of developments in the modern world. Building the intelligent machine by programming was a major contribution of the digital computer to Artificial Intelligence. In the 1940's, Artificial Neural Networks were introduced as the very first AI program that can be trained for numeric data. However, in the early days, many people believed that intelligence has a strong connection only with symbolic processing (symbolic AI) in terms of logic, rules, sentences and strings. As such, during 1950's to late 1980's, the AI community put much emphasis on cognitive systems approach to intelligence, and was very critical of the machine learning approach. This trend continued for 30 years until machine learning was reborn in a new shape. Nowadays, cognitive systems and machine learning are beneficial to each other.

4. Foundation of AI

The term intelligence is not the property of a single subject area. As such the foundation of AI comprises various foundation stones including philosophy, mathematics, computer science, computer engineering, cybernetics, education, linguistics, neuroscience, basic science, and control theory. Philosophers have debated a lot about the term intelligence, and the benefits and limits of building intelligence into machines. Role of mathematics and statistics is inevitable in the context of intelligence. For instance, when AI becomes a science, mathematical reasoning and statistical inference work as some cornerstones of AI. Mathematics also provides the foundation for the concept of algorithms, which is used to program intelligence into machines.

Among others, computer science has offered a unique contribution, which enabled building intelligent machines as programming exercise. This has been possible since the computer is a machine that can be programmed to implement virtually any phenomena, provided that you know about the phenomena. As such, computer engineering should also get the credit for developing a programable machine like the computer. Development of the Internet and related technologies (cybernetics) has enabled AI to operate in distributed and interconnected environments.

Theories of education and linguistics are influential for building machines with the capability to learn and to do communications using Natural Languages such as English, Sinhala, Tamil, etc. The fast-growing areas of natural language understanding, machine translations, and chatbots, demonstrates the influence of linguistics on AI. Machine-machine communication and discovery of new knowledge by the machines would be an exciting future development of AI as powered by theories of linguistics and natural language processing.

Undoubtedly, neuroscience has made an unprecedented contribution to the development of AI. Neuroscience discovery of human brain as a network of massively connected neurons, was the foundation for the very first AI technology, Artificial Neural Networks, which was introduced in the mid-1940's. Future development of AI has also been very much influenced by neuroscience concepts such as neuroplasticity and EEG. In section 7 of this article, more details are given of the effect of neuroscience for future of AI.

Influence of basic sciences such as physics, chemistry and biology on AI is noncomparable. For instance, quantum theory in physics/chemistry has influenced the building of quntum computers. Credit should also go to biology for the development of AI technologies such as Artificial Neural Networks, Genetic Algorithms, Evolutionary computing, Multi Agent Systems, and Computer Vison. We should not forget that all artifacts are engineered on the basis of some scientific theories. The same scientific theory enables building of various artifacts. For instance, Ohm's law (V=IR) is the science behind all electrical, electronics and computing devices.

5. Development of AI

Cognitive systems approach to AI dominated the early development of AI. In fact, from early-1960s to mid-1980, machine learning was excluded from AI due to a serious criticism made by Prof. Marvin Minsky, a co-father of AI. Many AI programs including DART, Pathfinder and Deep Blue come under cognitive systems. However, until late 1980's, AI could not win the industry recognition and

trust among the general public. Nevertheless, by mid-1990, theories in AI were developed by adopting the scientific method. This has resulted in eye opening of people who could not believe in the power of AI.

By early 2000, in view of the advancements of computing technologies, research in almost all subject areas began to generate massive collection of data in the respective areas. On the other hand, social media, online transactions, web services, IoT (Internet of Things), and so on also recorded an exponential growth of real-time data, which are dynamic, noisy, incomplete, and virtually non-algorithmic by nature. As such, analysis, modelling and predictions on such data turned out to be a compelling need of the modern world. This has created a golden opportunity for machine learning techniques to expand into areas such as deep learning. Since 2000, many AI programs including Watson and AlphaGo demonstrated the power of machine learning. In the recent past, fantasy of machine learning causesd people to forget about the other side of AI, which is cognitive systems. Machine learning suffers from the inevitable issue of giving solutions without justifications. However, people have gradually recognized the importance of the hybrid approach to machine learning and cognitive systems for smarter AI solutions for complex real-world problems.

In the late 1990's, Agent technology emerged as a new programming paradigm for computing. Inspiration for Agent comes from behavior of entities such as bees, ants, etc. It is evident that operations of any massive system such as human body, sun, brain, bee-colony, etc. are governed by functions of tiny entities (Agents) such as cells, atoms, neurons, bees, etc. As inspired from such natural systems, we define the concept of Software Agent as a small computer program that can perform a specific task and communicate with each other. The concept of Agent can be used to build solutions for parallel and distributed complex systems undergoing so much of uncertainty and unpredictability. According to Agent technology, intelligence can be defined as an emergent feature of the brain due to interaction among the neurons.

The emergent feature should be identified as a property that does not become available with an individual agent at the beginning but comes up as a result of interaction among agents. In group discussions, members sometimes start with zero knowledge about a matter but after certain deliberations, they come up with amazing intelligence to generate exciting solutions. Agent-based modeling has already become the new approach to build intelligent machines.

6. Four schools of thoughts

As a fast-growing area, different people approach AI with different goals in mind. Having multiple definitions or lacking an exact definition for the goal of a discipline, should not be considered as a weakness of the discipline. In reality, when people attempt to establish multiple viewpoints, it flourishes as a discipline. For instance, according to Dolton's theory the atom is unbreakable, but Einstein's atom can be broken, and could generate nuclear energy, while Schrodinger's atom has uncertainty in existence. All these three viewpoints are valid within their scope. As another example, during the time of the Buddha there were 62 different schools of thought about life after death, and this environment stimulate a creative fusion for establishment of Buddhism.

There are four major viewpoints or schools of thought in AI. These schools offer four different viewpoints to build intelligent machines. These views are primarily based on two concepts: thinking and behaving as the main aspects of intelligence.

Acting Humanly

According to this school of thought, AI strives to build intelligence machines that can behave like humans. Perhaps this is the oldest and the most familiar notion of the intelligent machine for many people. We have already seen many AI programs such as Expert Systems, Game Player, Problems solvers, which behave like humans. However, this school of thought does not promote to exploit intelligent features of animals (e.g. bees, ants) to build intelligent machines. This school of thought has a lap in ignoring the importance of animal intelligence to building intelligent machines.

Thinking humanly

This school of thought says that objective of AI is to build intelligent machines that can think like humans. We are aware of many activities that require thinking,

and they are already built into machines. As examples, when we play a game, solve a problem or design an artifact we need thinking. Many game-playing and problems solving programs have already been developed as intelligent software. Some people argue that thinking is yet another undefined term. However, although we cannot define thinking exactly, we are sufficiently aware of tasks for which we need thinking.

Thinking Rationally

The thinking rationally school of thought defines the goal of AI as building machines that can implement logical thinking. Logic has been the most powerful way to draw acceptable conclusions. That is why logic is used in mathematics, science, engineering, and court of law for drawing conclusions. Although logic is very precise in representing knowledge, it cannot always guarantee to generate a solution. More importantly, the order in which the logical statements have been treated has big impact on efficiency of reaching to a logical conclusion. However, many AI systems such as Expert Systems, NLP, Multi Agent Systems, Ontology are built as logic-based solutions.

Acting Rationally

This school of thought defines the goal of AI as building machine that can do the right thing. Here the term right has many meanings including doing most appropriate, optimal, and practical thing. For instance, if a home robot preparing a cup of tea and come to you with a piece of chocolate when no sugar is at home, you might say that this robot is intelligent. In the absence of sugar, taking chocolate is a right thing to do, rather than terminating the execution of the tea preparation algorithm. If the robot is limited to think like human or become logical, tea will not come to you. Building rational agents is considered as a modern approach to AI.

7. Future trends of AI

Having witnessed the amazing power of AI, many people are now so much excited to hear about the future of AI. There are also multiple views on the future of AI. Some people say that AI ends human race. Another set of people argue that AI would be the champion of the technological singularity in which machines surpass mankind. We should not forget that everything has a bad side as well as a good side. For instance, Einstein's atomic theory can generate electricity for the betterment of mankind, but the same atomic theory can also build atomic bombs to destroy mankind. One can argue the same for AI. However, what is important is the way we use AI. Here I will take a more positive approach to views on the future of AI. In this sense, I use man-machine coexistence as the broader picture of the future of AI. Under man-machine coexistence, many future trends in AI can be discussed.

Man-machine coexistence

Man-machine coexistence envisages human and machines working together rather than competing with each other. In this context, the difference between man and the machine will be reduced, and tend to be very similar to each other. Just like the relationships between human and human, man-machine coexistence should enable sharing resources and transplanting/implanting organs and AI chips. In the 1990's, science fiction terminator, demonstrated the concept of using a biological brain within a robot. Nowadays, this has become a reality and successful experiments have been conducted to build robots with rat brains. Implanting AI chips in brains have already taken place at the therapeutic level and will be developed as a means of improving cognitive capabilities of human beings in the future.

Bionic and Cyborgs

Future of AI will be very much influenced by the advancements of neuroscience. Concepts such as neuroplasticity and electroencephalography (EEG) have identified ways and means of capturing electrical activity of the functioning brain, analyzing EEG signals to do various research about the brain. Methods have also been discovered to identify electrical activity of the functional muscles which also comprises of neurons. Such developments have postulated extending the physical capabilities of humans with the support from mechanical and electronic devices. The concept of biologically inspired engineering, known as Bionics, was also born in late 1950's. Developments in AI and Bionics have contributed to establishing another area known as cyborgs, which talks of extended biological beings (e.g. humans) with AI chips. Humans are increasingly becoming cyborgs. Operations of such beings are manifested by interfacing between brain and the machine. For instance, artificial body parts, generally known as

prosthetic, are now interfaced with the brain via Bluetooth technology. Such prosthetics uses EEG waves from the brain to control the body part in a natural manner.

Hybrid intelligence

Ray Kurzweil, the Arthur Clark of AI, predicts that in 2040 researchers will discover more areas in the brain and their specific functions. He also talks of what is called hybrid intelligence, which comes from a brain with one-part being the biological brain, and the other part comprising some AI chips. One of the biological brain, or the AI chip works at a given time, just like way a battery or engine works in hybrid vehicles. Obviously, the hybrid intelligence gives an opportunity for extending the cognitive capacities of humans and animals. This technology can also be extended to reach a desired level of relaxation of the biological brain of humans, by dedicating a relevant cognitive task to an AI chip. For example, if a driver feels sleepy, AI chip will undertake autonomous driving. Although AI chips have already been implanted in the human brain as therapeutic measures, there are not much discussion about hybrid intelligence.

Mind uploading

Building digital copies of biological brains of humans is emerging as a new research area. Here the digital copy of the brain stands for AI programs such as Artificial Neural Networks (ANN). For instance, in mind uploading, researchers strive to capture EEG waves created by a human brain when executing a certain task such as solving mathematical problems. Then the EEG waves will be used to build an ANN. In this manner, researchers intend to build digital copies of the human brain. This kind of researches enable us to come up with new means of preserving brains of scholars. On the other hand, the developed EEG based ANN of a scholar can be used to stimulate a brain of another person to achieve certain cognitive skills of the second person. These researches are currently being experimented with animals. For example, EEG based ANN of a trained dog can be used to stimulate a puppy's brain to achieve faster training of the puppy.

Biological programming

Another prediction by Ray Kurzweil says that in the future we will be able to program a human being, may be at the genetic level, to cure certain diseases such as cancer. Technically speaking, conducting a lecture can also be considered as programing of students to be able to certain tasks. All of us can be seen as programmed human beings by our parents, teachers and the society. In the near future, programing living cells may be as common as programming computers. Researchers at MIT have already developed tools to design DNA circuits for living cells. Undisputedly, biological programming will revolutionize the future of mankind in terms of education, medical treatments and even personality development.

8. Summary

This article has discussed the evolution of Artificial Intelligence from its inception to possible future trends in AI. According to John McCarthy, we understand AI as science and engineering of building intelligent machines. The article presented a brain as a nice analogy to understand scope of AI in a simple manner. We emphasize that AI is about building models of natural intelligence into machines. Then we introduced two broad areas of AI as cognitive systems and machine learning. Gestation of AI, foundation of AI, developments of AI, four schools of thoughts and future trends in Ai were also discussed. Influence of neuroscience for future development of AI was also highlighted. Man-machine coexistence, bionics/cyborgs, hybrid intelligence, mind uploading, and biological programming have been discussed under future trends in AI. This article pointed out that the future of AI will be heading to a society with man-machine coexistence, where the gap between man and machines will be increasingly reduced. Although singularity is coming, we take a positive standpoint that AI will not surpass mankind, yet support the well-being of mankind in numerous ways.

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Applications of AI at National Level

Dr Ruwan Weerasinghe

Preamble

Artificial Intelligence (AI) is often referred to as a single technology, when in fact it actually refers to a combination of a wide range of technologies. These include those such as intelligent search, knowledge representation, reasoning, speech and language processing, computer vision, machine learning and optimization. Over the past 50 years or so, some of these technologies have matured to states where they are now being widely deployed in solving human problems, instead of being limited to university laboratories.

Language foundation

A pre-requisite for leveraging AI at National level in Sri Lanka, is localization and language processing in and for the national languages of Sinhala and Tamil. This involves developing both linguistic resources and key technologies required for processing these local languages. Once this 'infrastructure' is set in place, AI applications can be deployed at national level to solve problems based on development priorities.

Some of the key local language technology applications include optical character recognition (OCR) by which printed material in hard copy can be digitized to editable form, text-to-speech (TTS) by which digitized text can be spoken out aloud by the computer automatically, speech recognition (ASR) by which human speech can be directly digitized and machine translated by which text or speech in one language can be translated to another. These technologies in combination could for instance allow a blind person to scan a document using their smart phone which performs OCR followed by TTS, to enable the written work to be read out loud, so that the blind could (metaphorically) 'see'.

Machine learning

What drives AI at present is machine learning. While classical information technology used algorithms to manipulate data in order to arrive at results, machine learning is about using the data and results in order to obtain the 'algorithm'. In particular, in supervised machine learning, the system 'learns' from past examples which have been solved by humans, and generalizes this knowledge in order to build predictive systems for deployment.

While a majority of such machine learning tasks utilize structured data from data sources such as organizational databases, unstructured data such as image/vision, speech and language can also be used for learning tasks automatically using machine learning.

AI applications

A common example of the above kind of supervised learning is the prediction of credit worthiness of customers to a business. While the banking, finance and insurance industries are the most obvious beneficiaries of such a system, any business having to make decisions about the level of credit that can be extended to its customers can use such a system. This could also be employed by various state, Non Government Organization (NGO) and private sector micro-credit operations to lend to the most trustworthy parties, so that the funds remain in circulation for the benefit of a maximum number of potential beneficiaries.

Another common business related AI application is for churn prediction – i.e. predicting the customers or employees who are most likely to leave one's business or brand. With appropriate data, even state organizations can 'train' supervised learning algorithms to help identify employees who are most likely to be disgruntled and so likely to leave the organization, so that some intervention can be made to avoid it, if the organization is going to be negatively affected by it. For businesses, apart from losing employees, losing customers to competitors is a serious problem. Being able to predict customer churn, a business would be able to target deals and discounts needed to mitigate such 'migration'.
Sri Lanka can also use data collected by the police, currently in written, and therefore hard-to-use form, to discover unforeseen associations between criminals, in order to detect and track down their networks. Association rule mining and network analysis are two machine learning techniques that could be used in this kind of task. While predictive policing has been criticized for being intrusive, more conciliatory approaches to deal with information extracted from criminal data to predict which members of society could potential fall prey to such networks, would be beneficial especially for probation services.

Biometric analysis is a related application for assisting law enforcement agencies. Already finger print identification systems are able to uncover many a crime that previously went undetected. Other forms of biometric identification including iris scanning, blood flow and DNA finger printing will allow ever increasing accuracy in ascertaining the truth in cases of prosecution. These systems can also of course be used in non-criminal settings such as for access control to premises.

One of the most topical issues facing Sri Lanka in the recent past has been the fake news phenomenon. It has become increasingly difficult to identify fake news owing to the sheer proliferation of news and gossip. Modeling the credibility of news sources using network analysis is becoming an essential task, in order to make our population more discerning. The related social media phenomenon of hate speech on the other hand can be more directly dealt with using a supervised learning approach, based on data collection and annotation. Credibility networks can also be effectively employed on journalists, politicians, academics, lawyers and doctors in order to weigh multiple competing 'truths'.

A very useful service that currently provides access to government information is the 1919 call center. Unfortunately, the call center only operates during daytime for practical reasons. Replacing its core activities using a conversational agent (chatbot) would not only allow 24-hour service, it would also free up human resources during the daytime, since only matters beyond the scope of the chatbot would ever be referred to a human operator. Chatbots could also assist all kinds of citizen service providers, including state organizations.

Sports analytics is a new area which is becoming popular in many countries and could potentially help Sri Lanka identify sports and athletic talent at school level by matching body types with appropriate types of sports, in order to better streamline our talent pool. In addition to this, analytics could also professionalize many of our sports by gamifying athletic performance. It could also provide the platform for unbiased selection for district, provincial and national level teams in a transparent way, based purely on pre-defined objective metrics.
The common thread running through all the above applications is that all decision making in these scenarios is evidence-based. This kind of decision making will free Sri Lanka from the clutches of favouritism and bias, thus allowing a level playing field for a maximum number of participants to compete with each other in order to realize the best benefits for the country as a whole.

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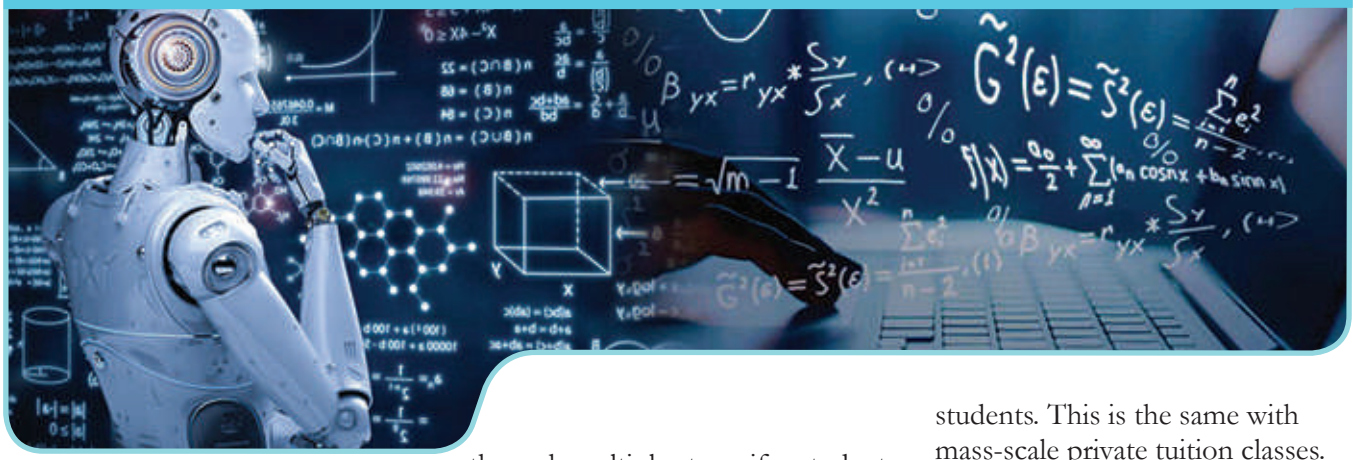
AI in Education – A Problem-based Learning System for Mathematics (MathsTutor)

Dr Surangika Ranathunga



Mathematics is undoubtedly one of the most difficult subjects in the Ordinary Level (O/L) examination. Statistics show that close to 50% of the students fail mathematics in the GCE O/L examination. Many students find mathematics difficult because, unlike many other subjects, it is not possible to memorize mathematical theories/concepts and answer the exam paper. Rather, the student is expected to demonstrate that she can apply the learned theories and concepts in solving unseen mathematical problems. The best way to excel in mathematics is to practice solving many such mathematical problems. For many of these mathematical problems, partial marks are allocated to the intermediate steps of the solution. Therefore, the student should know the correct procedure to solve a mathematical problem. Moreover, when the Mathematical problem has to be solved through multiple steps, if a student makes a mistake in her solution, she cannot figure out the mistake simply by looking at the final answer. In such cases, a teacher will have to assist the student in identifying her mistake, and giving proper feedback. However, there is a scarcity of good mathematics teachers in many schools, and the available teachers do not have adequate time to allocate for personalized feedback to all the students. This is the same with mass-scale private tuition classes.

A solution to this problem can be provided with the help of computers, more specifically with the help of Artificial Intelligence (AI). This article presents such a system that is currently being developed by the Department of Computer Science and Engineering, University of Moratuwa. The aim of this system is to be capable of generating new questions, generating answers to these

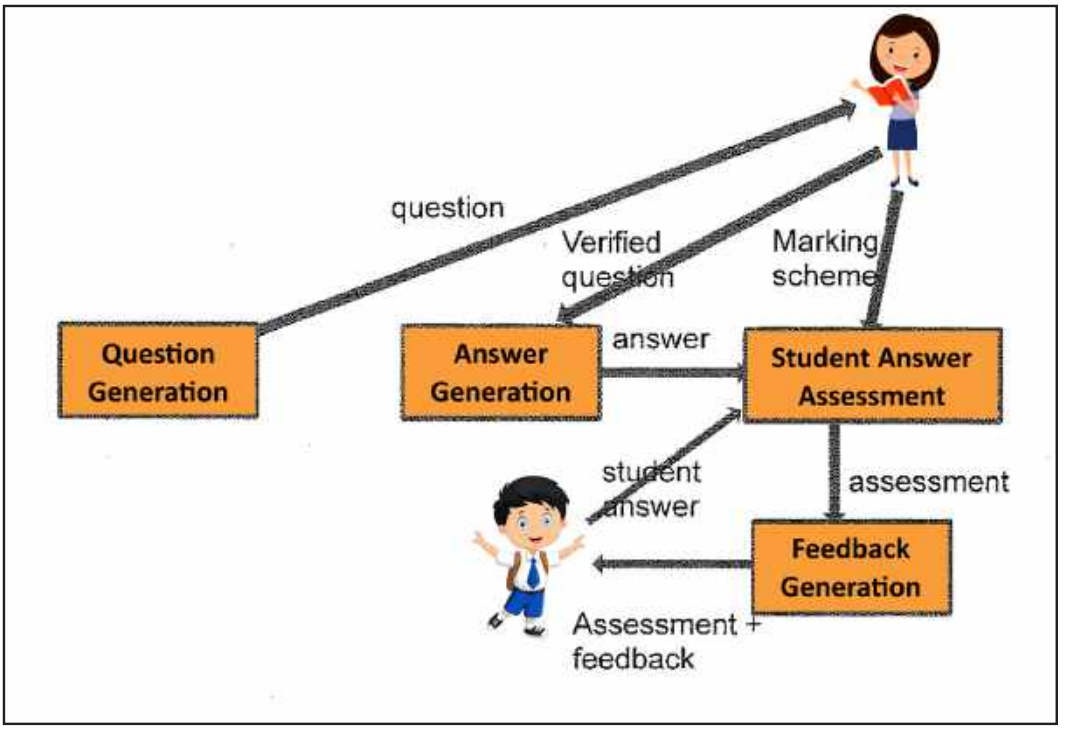


Fig 1 : Maths Tutor System

questions, assessing student answers according to a marking scheme, and to provide feedback to individual students. We call this system as MathsTutor. AI is a very broad field of study, and is broken into several sub-problems. The main sub-fields include reasoning, knowledge representation, planning, learning (Machine Learning (ML)), Natural Language Processing (NLP), and perception.

generates answers to these mathematics questions. When a student submits her answer, it is compared with the system generated answer. If a teacher provides a marking scheme, then marks are allocated to the student's answer. If the answer is wrong/ partially correct, the system provides feedback to the student.

Although this system looks simple, its implementation is quite challenging. Different questions are written down in different formats, and are solved in different ways. For example, in O/L mathematics, quadratic questions and simultaneous questions mainly have mathematical equations, with little text in natural language. In contrast, Geometric construction questions have detailed textual descriptions, and Venn diagrams have a detailed description and an associated diagram. Thus, based on the type of the questions, different techniques have to be applied to process them. Therefore, we followed a divide-and-conquer approach in implementing MathsTutor, where different components in the system are separately implemented for different questions. The

main advantage of this kind of modular approach is that different components of the system can be used without having to rely on other components. For example, the teacher can provide a question she created and get the machine to generate the answer. Similarly, she can manually provide the sample answer along with the marking scheme for the system to assess the student's answer.

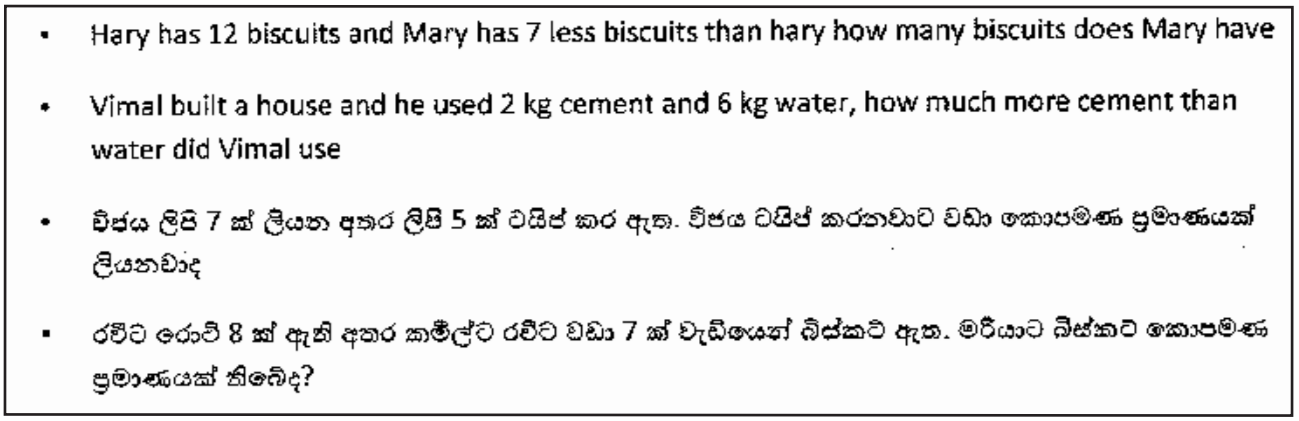


Fig 2 : System generated Sinhala and English elementary Mathematics questions

MathsTutor is based on NLP, ML, and reasoning.

It is important to note that MathsTutor is not intended to completely remove the teacher from the learning process of the student. This is the same with many other AI applications. Rather, the teacher is expected to play the role of a verifier and a facilitator, so that with the available time the teacher can serve/support more students.

Figure 1 shows how the MathsTutor system will look, when it is fully implemented. As can be seen, MathsTutor is capable of generating mathematics questions. The generated questions may not be 100% accurate. Therefore a teacher is expected to verify them. Once verified, MathsTutor

The manner in which we implemented the system components for some questions is discussed below.

Question Generation

Here we first focus on generating questions that have only textual descriptions. This is a problem of Natural Language Processing, which is a sub-field of AI. In particular, this is a problem of Natural Language Generation. This is implemented with a state-of-the-art Deep Learning technique called Long-Short-Term Memory (LSTM) network. Generating text using this type of deep learning techniques is known as 'neural language generation'.
The power of this technique is that it can generate questions for

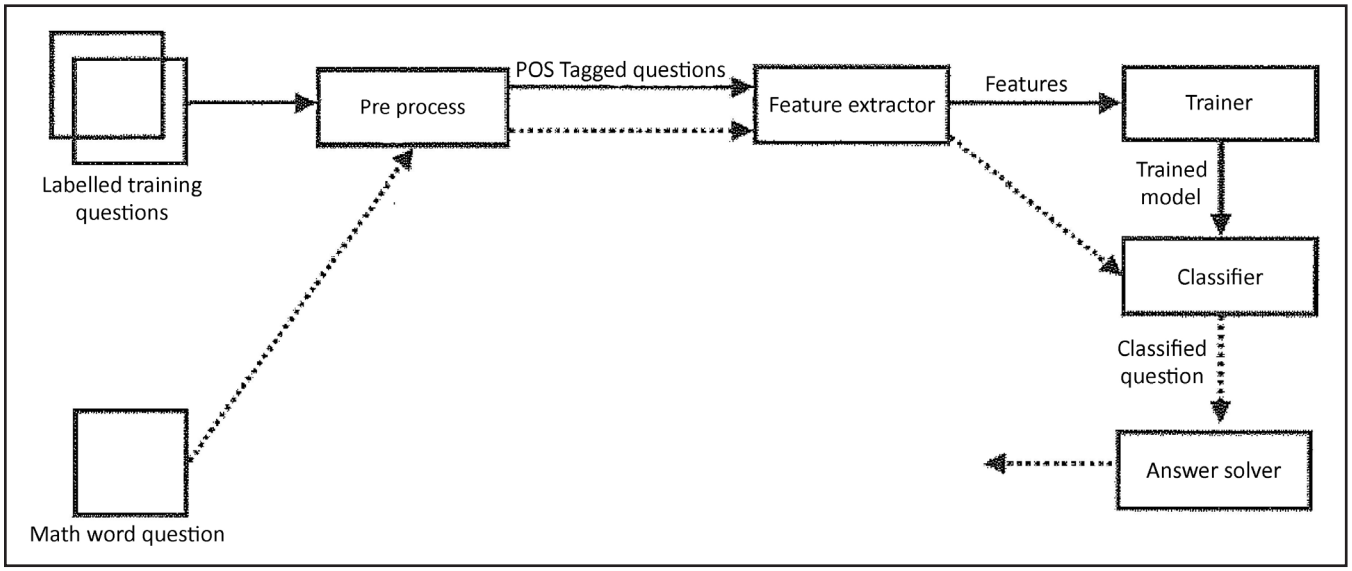


Fig 3 : System for generating answers for elementary Mathematics questions

Change Type: Pete had 3 apples. Ann gave Pete 5 more apples, how many apples does Pete have now?

Compare type: Joe has 3 balloons. His sister Connie has 5 balloons. How many more balloons does Connie have than Joe?

Whole-part type: There are 6 boys and 8 girls in the volleyball team. How many children are in the team?

Fig 4 : Elementary Mathematics Questions that can be handled by the answer generator

any language, given that there is a sample set of similar questions. Currently we are generating simple elementary Mathematics questions as the ones shown in Figure 2. As can be seen, the generated questions are not 100% correct. Therefore at this stage, we have to keep the teacher in the loop, where the teacher will finalize the generated question. From the evaluations we carried out, we found out that teachers find it more efficient to correct the machine-generated question rather than writing a question from scratch.

Answer Generation

The implementation of this module is very much dependent on the type of question. Current system can support simple elementary mathematics and Venn diagram questions. Some sample questions are shown below.
Figure 3 shows the system that generates answers for simple elementary Mathematics. This is a system that makes use of Machine Learning, another sub-area of AI. Here a Machine Learning classification algorithm is trained with a sample set of question-answer pairs. The task of pre-processing and feature extractor is to convert the question into a format that can be understood by the classifier. The task of the classification algorithm is to identify the type of the question, for which an answer should be generated. Answer generation is done by the 'Answer Solver'. The types of questions (change, compare, whole-part) handled by this classifier are shown in Figure 4.

Answer Assessment

Answer assessment module is the one that is the most complete module at the moment. MathsTutor

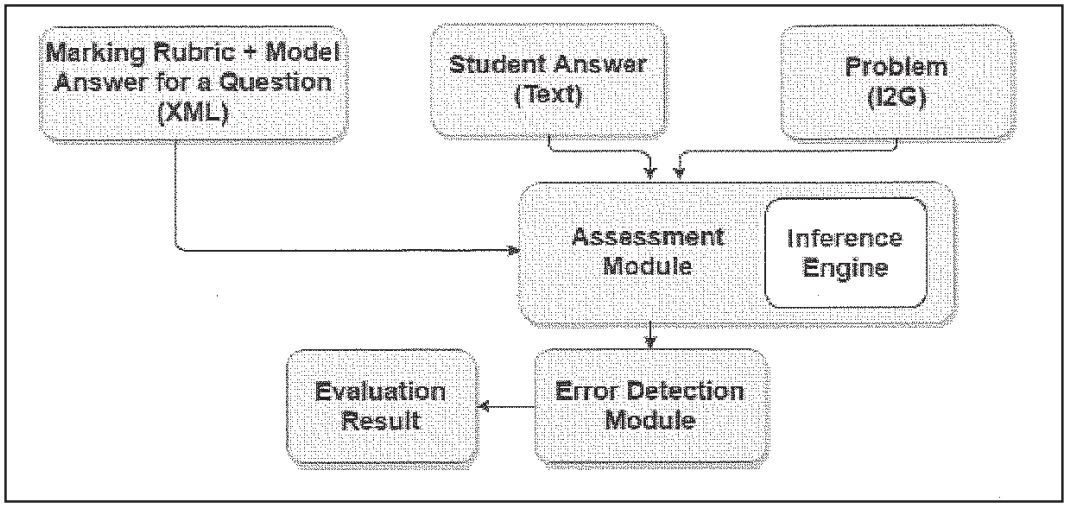


Fig 5 : System to assess Geometric theorem proving questions

In triangle ABC, AB=AC. The line drawn parallel to AC through D; the mid-point of AB, meets BC at F. AC is produced up to E such that BD=CE.

Show that,

I. DBF and DFB are equal angles

II.DFO and ECO triangles are congruent

III.OC = (1/4) BC

IV.DFEC is a parallelogram.

Fig 6 : An example Geometric theorem proving question that can be handled by the system

can currently support following types of questions.

•Geometric theorem proving
•Geometric constructions
•Venn diagrams
•Algebraic Math word problems
•Linear and Simultaneous equations

The system to assess Geometric theorem proving questions is shown in Figure 5. Here, the inference engine is based on a concept called 'Reasoning', which is another sub-field of AI. Moreover, the student answer and the problem text have to be converted into a machine-understandable format. In order to do that, the natural language text should be 'parsed' to extract the meaningful elements as those shown in Figure 5. An example question that can be handled is shown in Figure 6.

Future Work

We are still working on improving and completing the MathsTutor system. None of the components provide 100% accuracy, and teacher input is needed to do the final validation. However, as mentioned earlier, when teachers have only to validate rather than to create questions/answers or grade from scratch, they are more efficient and can support more students.

Only some components such as the question generator are language independent. Many other components work only for English, therefore local language support should also be added. Another main drawback of Mathstutor is that it expects the teachers and students to 'type-in' their input. Especially when writing student answers, this might alter the student's thought process. Therefore we plan to start integrate Optical Character Recognition (OCR), which is another sub-field of NLP in order to read hand-written text. Once the OCR component is added, the student can simply take a picture of her answer and upload it to the MathsTutor system.
Once fully implemented, Maths Tutor can be accessed through a web interface, so that any student or teacher can use the system from anywhere in the country/world.

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AI for Tomorrow
What AI can deliver for us tomorrow

Dr Subha Fernando

Introduction

We are at the dawn of the fourth industrial revolution in which Artificial Intelligence is a core element of this revolution. Artificial intelligence (AI) is a combined area of computer science, mathematics, and statistics, which involves the study of machines that are able not only to work and to think, but also to respond as we human beings. Since most have still not realized how powerful AI will become tomorrow, it is hard to recognize how significantly this technology can improve the way we work. AI research and its applications are continuously growing. According to technology writers, AI research has grown by 12.9% annually worldwide over the last five years. According to the world's leading research and advisory companies, enterprise adoption of AI has increased 270% during the last four years.

There are seven distinct research areas that are very significant in AI research: search and optimization (evolutionary computing), fuzzy systems, natural language processing, ontology and knowledge representations, computer vision, machine learning and probabilistic reasoning, planning and decision making. In today's AI, machine learning (deep learning is a specific branch of machine learning) and probabilistic reasoning, computer vision and natural language processing show the most substantial volume of research growth in AI.

This article explores the processing flow of AI system in the form of a flowchart of key technological processes, and discusses what AI has delivered today, and what it will deliver tomorrow, and finally the expectations in advancement of technologies in AI in the future.

Overview of AI System

The flowchart (Figure.1.) shows the main processes of an AI system. As shown in the flowchart, any AI system reads its environment and responds to the environment according to its objectives. The growth of applications and researches in the Internet of Things (IoT) has advanced the way AI could read and respond to its environment.

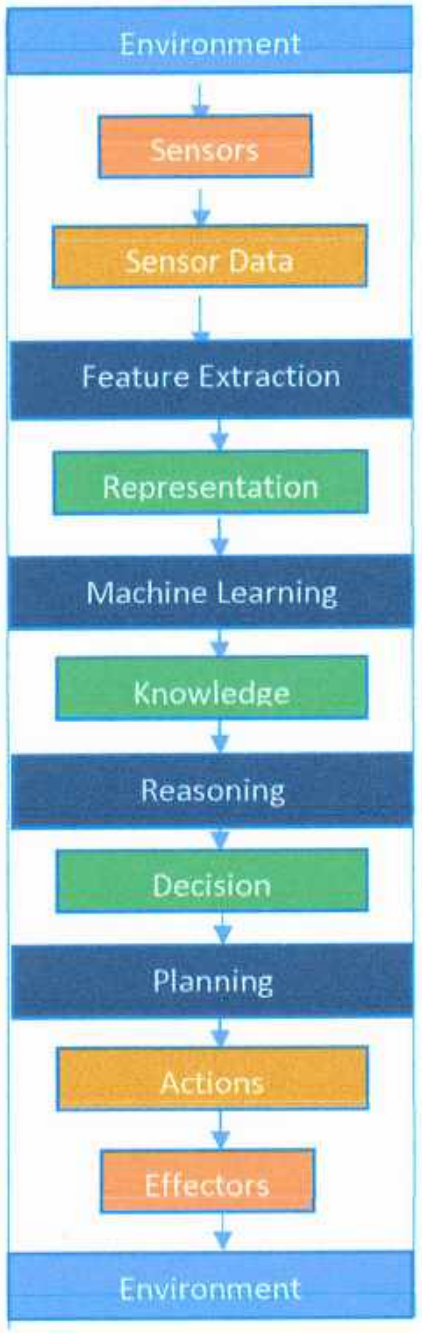
The first two processes in the flowchart, do read the situated environment where it interacts through sensors and, collects data. For example, collecting images from CCTV footages, collecting images from crops, collecting images of skin diseases, reading web blogs, reading reviews, listening to music, listening to a dialogue, etc. are examples of the first two processes. Once the data are collected, then by using deep learning algorithms: the most powerful technology of today's AI, is used to extract features, identify, and understand what you have sensed in the form of images, videos, audios, text, etc.

Then by using appropriate knowledge generation and knowledge evolving technologies in AI, such as machine learning or rules engines, from extracted features, a piece of knowledge is generated which explains the situation of the outside environment relative to the intelligence of the machine. For example, if this generated knowledge which is developed by applying machine learning algorithms and rules engine, is powerful; then it can understand complex behaviours on the dynamic environment such as identifying of unusual behaviours within a shopping mall, violations

of traffic rules on highly congested environment, non-ethical posts on Facebook, etc.
After knowledge generation, it comes to reasoning, and the planning phases, where the system reasons out its understanding about the current situation against its design objectives. It will help to make an optimal decision based on its understanding and available intelligence to reach the design objectives (the list of tasks that that has been delegated to be executed). Once it makes its decision, it comes up with a sequence of actions, referred to as a plan in AI, to execute its decision on the environment. These actions are connected to effectors which could be IoT devices that can be executed on the environment. These effectors can write, speak or draw images, or even assign a task to an external robot. These are possible today because of deep learning and other machine learning technologies. However, reasoning and planning is an area that still needs huge attention in making an optimized decision, based on the understanding, intelligence, sensors and effectors of the system.

AI for today and tomorrow – Industrial Perspective

Today we have very business-specific or single-purpose artificial intelligence known as narrow intelligence. An AI program or a robot, is a piece of hardware that has been programmed to do a specific task, fallen under the era of narrow intelligence. You can imagine an AI system which has expertise in the business task, such as to identify vehicles that violate traffic rules only. These systems are designed in a way that



have mastered or have expertise in performing a single business task. If they are trained to identify criminals, they can not be employed to detect intruders. Let us discuss how AI has been adopted by some industries for their tomorrow's tasks:

Manufacturing Industry:

In the manufacturing industry, major companies like General Electric (in 2018, GE is ranked as the 18th-largest firm in the U.S. based on the gross revenue), Siemens, Intel, NVIDIA, and Microsoft are moving towards the concept of smart manufacturing (it is also called industrial IoT and AI). According to recent market reports, the global manufacturing market will increase to over $320 billion by 2020 compared to $200 billion in 2019. They are trying to bring down labour costs, reduce the product defects, increase the production speed, and shorten the downtime by introducing industrial robots and machine learning. Because of massive investments on industrial robots in the manufacturing industry, according to the International Federation of Robotics, in future, more attention will forcussed on how to establish human-robot collaboration. This collaboration is required to be ensure safety and efficiency as more industrial robots are planned to move into the production floor. With the advancement of AI, these industrial robots will be able to handle more cognitive tasks and make autonomous decisions based on the exiting environment.

Agriculture Industry:

The agricultural industry is the oldest and the most important profession in the world. The industry is now adopting AI technologies in order to control pests, maximize the harvests, monitor soil and growing conditions, organize data for farmers, predict diseases, etc. Today the industry's main experiments in AI are on how to optimize the yield by determining right crops suited to the expected weather conditions, temperature and soil conditions.

Currently, a branch of the agriculture industry is now being transformed under the concept of precision agriculture, which uses AI technology to detect diseases in plants, nutrition deficiencies in plants, etc. In this business process, IoT devices enable reaching the target plants, while AI systems decide the amounts of fertilizers required for the given plant. Additionally, AI chatbots are used to answer agricultural questions and provide advice and recommendation on farming problems. Moreover, companies are developing autonomous robots to handle harvesting of crops at higher volume, with drone-technologies to monitor crop and soil health.

Education:

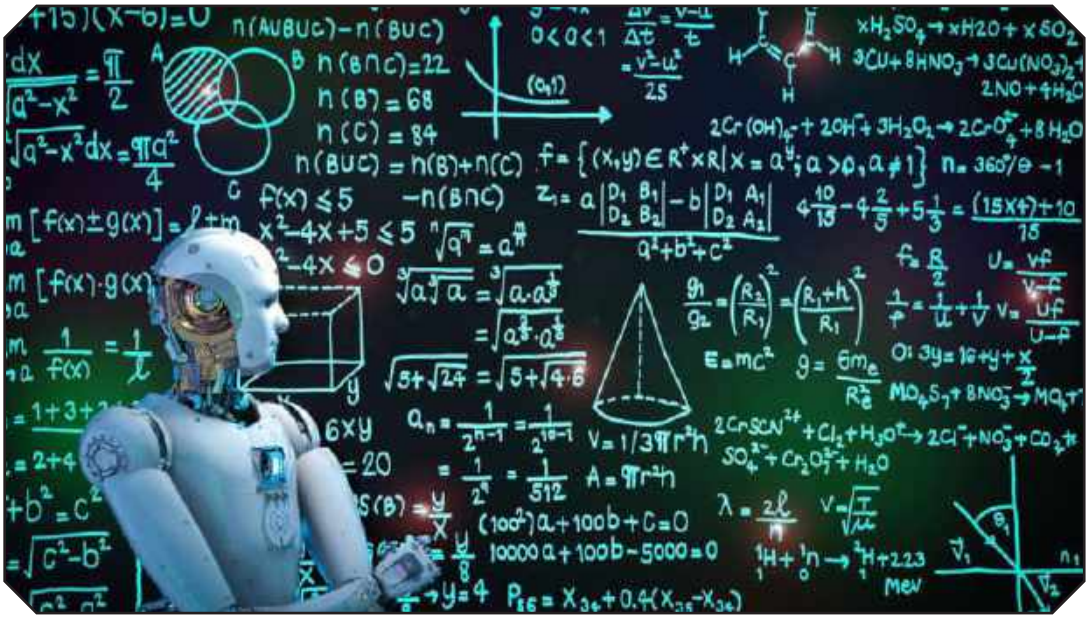
The rise in the use of information technology in classroom-activities in the education sector is impressive. In today's classroom, students are surrounded by smart boards, computers, laptops, and phones. Consequentially, this allows distance learning more practical, and reach greater audiences around the country and the world. With the dawn of the AI revolution, it is being predicted that AI will surely take over the administrative tasks of teachers, and may even replace teachers, or teacher-assistants within the classroom. Today IBM Watson, Third Space Learning and Duolingo Chatbot are forms of AI already being used to enhance learners' experiences. The development of AI in the education industry can be broadly seen under two significant aspects:

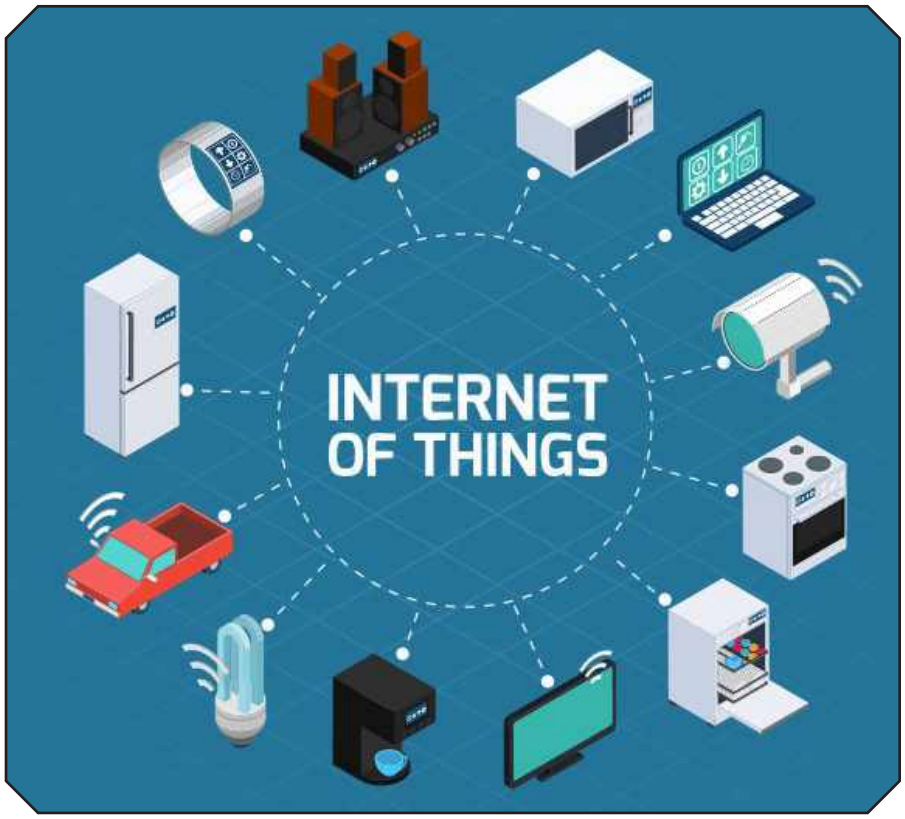
1.Automated admin tasks: Testing and grading consume a tremendous amount of time of the teachers. AI can step in and perform online or offline testing and gradings, while offering recommendations to the learner by closing learning gaps. For this purpose, computer vision and deep learning have been exploited to evaluate written answers with graphs.

2.Tutoring and personalized learning: AI supports to come in the form of chatbots to help learners with subject streams, such as Algebra, Science, English, etc. For example, an educational application has been developed by Peter Wozniak, a Polish inventor, that keeps track of what you are learning. Using AI, the application finds out what you are likely to have forgotten, and recommend that you revise it. Further, many AI applications have been introduced in the form of chatbots that adapt to the learner's pace of learning, and consistently offer much more complex tasks to accelerate learning.

AI in the near future

In the near future we can expect artificial general intelligence (AGI), a technology that will work across business disciplines. Accordingly AGI will not be a single standalone system, but an integrated system of many narrow intelligence systems that could perform tasks or achieve delegated goals across many business disciplines. Such an AI system can be used to detect intruders, generate a statistical summary of people inside the building, predict their behaviours, the energy consumption of electrical devices, generate reports on usage of electrical equipment inside the building, predict their downtimes, etc. In the alternative one can imagine a chatbot on a mobile phone, which works as a personal assistant. It will be able to make food orders, make calls, re-organize your calendar activities that minimize conflicts, read newspapers and generate summaries, generate action-plan for today's meeting,





write and prepare documents for your meetings, identify your diseases, symptoms and suggest treatments, make appointment to a suitable doctor after checking your availability etc. As shown in this example, these general AI applications are much powerful than narrow AI and require more reasoning algorithms that could work across many disciplines.

Thus this general AI is the combination of specialized AI that creates increasingly sophisticated specialized intelligence that makes it massively capable. When you see autonomous vehicles on our roads, that plans the journey before hand, starts without any human help, planning the tour covering all the places we want to visit, finding the optimal path while responding to traffic jams and accidents, act on emergency situations, ability of overtaking, ability to connect with other autonomous devices, etc.

then you are in the era of artificial general intelligence.

AI in future

Artificial Super Intelligence (ASI) is the way into the future. ASI will need to surpass human capability at absolutely everything. When an AI system is more capable than a human, then it is called ASI system. It is expected that ASI will be able to perform extraordinary work such as drawing arts under a given theme, develop self-awareness, develop common knowledge, establish emotional relationships, etc.

For the scientists, the main challenge they may face when stepping towards ASI is establishing and improving the cognitive abilities of AI systems. Many research projects are working towards mimicking human brains, and its cognizance to machines.

The Blue Brain project is one such project initiated by Swiss brain research with the aim of constructing a digital form of human-brain by reverse-engineering of mammalian brain circuits. In addition the, Google research team is aiming at developing quantum processors and devision quantum algorithms that will dramatically accelerate computing tasks for machine learning.

When the ASI, machines get more intelligent by learning, they will no longer depend or learning from humans. In such circumstances, ASI will be more powerful than human beings because of their capability of developing own-communication languages and societies without human help. Interaction with its society makes a human more powerful, practical and smarter. Similarly, the moment these ASI machines are capable of cognitive reasoning, develop self-awareness, self-learning, and developing own-communication language, a society of machines will be established, that will surpass the humans capability at absolutely everything.

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The Era of the 5G Drone is Ahead, Are We Ready?

Chaturanga Basnayake, Kanchana Osanda Lakmal, Prof Dushantha Nalin K. Jayakody

Just a few years ago, seeing a drone in the Sri Lanka's skies was as scarce as hen's teeth; today, improved technology and rapid adoption have made it common for every eye.

Unmanned Aerial Vehicles (UAV) or drones, as they are often called are aircraft that can fly without pilots or remote control. In the early 1900s, military researchers started UAV innovations, which originally focused on providing practice targets for training military personnel. With the influence of world wars, these researches expanded, and were used both for military trainings, as well as for arial attack missions in military campaigns. However, after 1980s, drones were not limited just for military purposes and they made their role prominent in surveillance and reconnaissance operations and in other civil applications, such as aerial crop surveys, fire detection and monitoring, urban management, large-accident investigation and coordinating humanitarian aids. For example, UAV has been seen as an active service in humanitarian operations undertaken by the government of Sri Lanka in 2009.

On the other hand, 5G use cases such as drone network. It has also come up with new challenges in order to coordinate drones, to ensure that they can fly safely in the air. The fifth-generation (5G) cellular network technology, with its low latency and greater capacity, has already proven its usefulness in the communication field, since all drone operators can operate their drones beyond line of sight distance with the help of 5G.

Diverse applications of UAVs such as weather forecasting, emergency response etc. are illustrated in figure 01. UAVs have now become highly helpful in times of distress due to the fact that now it is able to mount cameras on them. UAVs can be very useful in surveillance of disaster-affected areas, locate affected people and deliver aid and assess damage inflicted upon property. Furthermore, they have proven to be a feasible solution to provide emergency supplies and relief to stranded people in hard to reach areas during times of severe weather conditions. The application of UAV is not limited to disaster management, but also military activities. Furthermore, the use in defense marked the inception of the UAV and it is the most important area of application even today. The technology has evolved massively over time and portable UAVs being used by ground forces is a common sight at present. Military use UAVs mostly for surveillance and offensive operations. UAVs can help farmers in gathering data an automating some practices which could dramatically increase the efficiency which in turn would deliver better yields, which is a prime goal in the modern economy. Some of the applications of UAVs in agriculture include spray pesticides and other fertilizers to the fields, Seeding the fields of air at very high efficiency and speed, pollinate flowers which can well compensate for the declining bee population, etc.

Applications of UAV

In a smart city, the city will interconnect all public services using advanced and robust communications technologies. The cost and resource consumption within the city can be greatly reduced as a result of the interconnection between all the

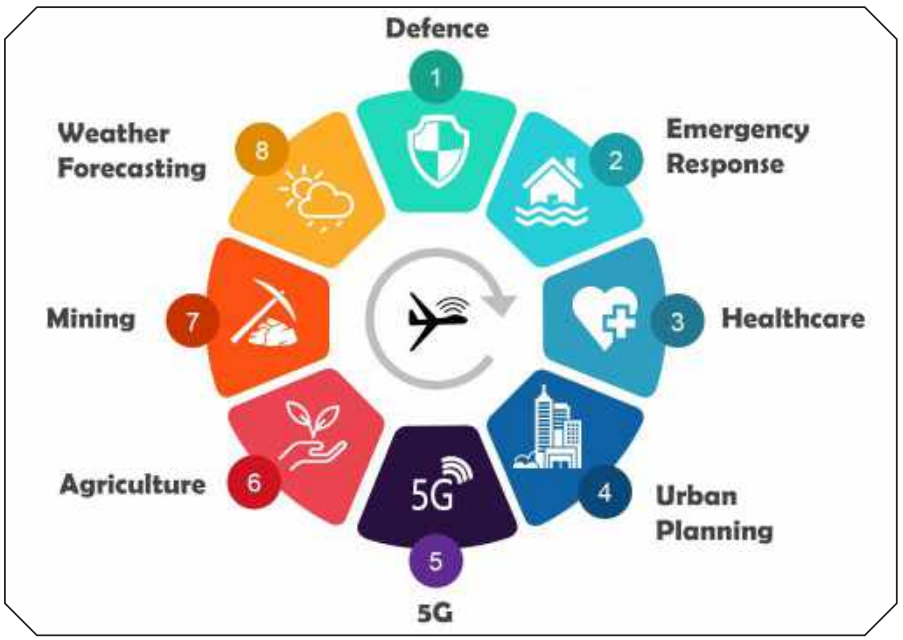

Fig 1 : Applications of UAV

services. UAVs can play a huge role in this whole interconnection process. For example, in a smart city, a call to the emergency services would immediately dispatch a well-equipped UAV to the location of the caller using the GPS (Global Positioning System)coordinates. Uninterrupted by traffic and the street lights UAVs can get to the scene in record time which can be crucial. With real-time video link to security forces vehicle, ambulance and other emergency vehicles attached, first responders would get an accurate scene assessment before they even arrive which could expedite the process and save that valuable second of the response time and save officers' lives when responding to a dangerous situation such as a riot or a shooting incident. This increases not only the response time of the emergency service personnel, but their own safety as well.

Since planes cannot remain airborne for long periods, and satellites are too far above the Earth's surface, aerial photographers cannot continue to rely on conventional aircraft, and consequently UAV act as an equivalent of satellites in the atmosphere. Nowadays, aerial photography and videography with UAV are ideal for the Sri Lankan

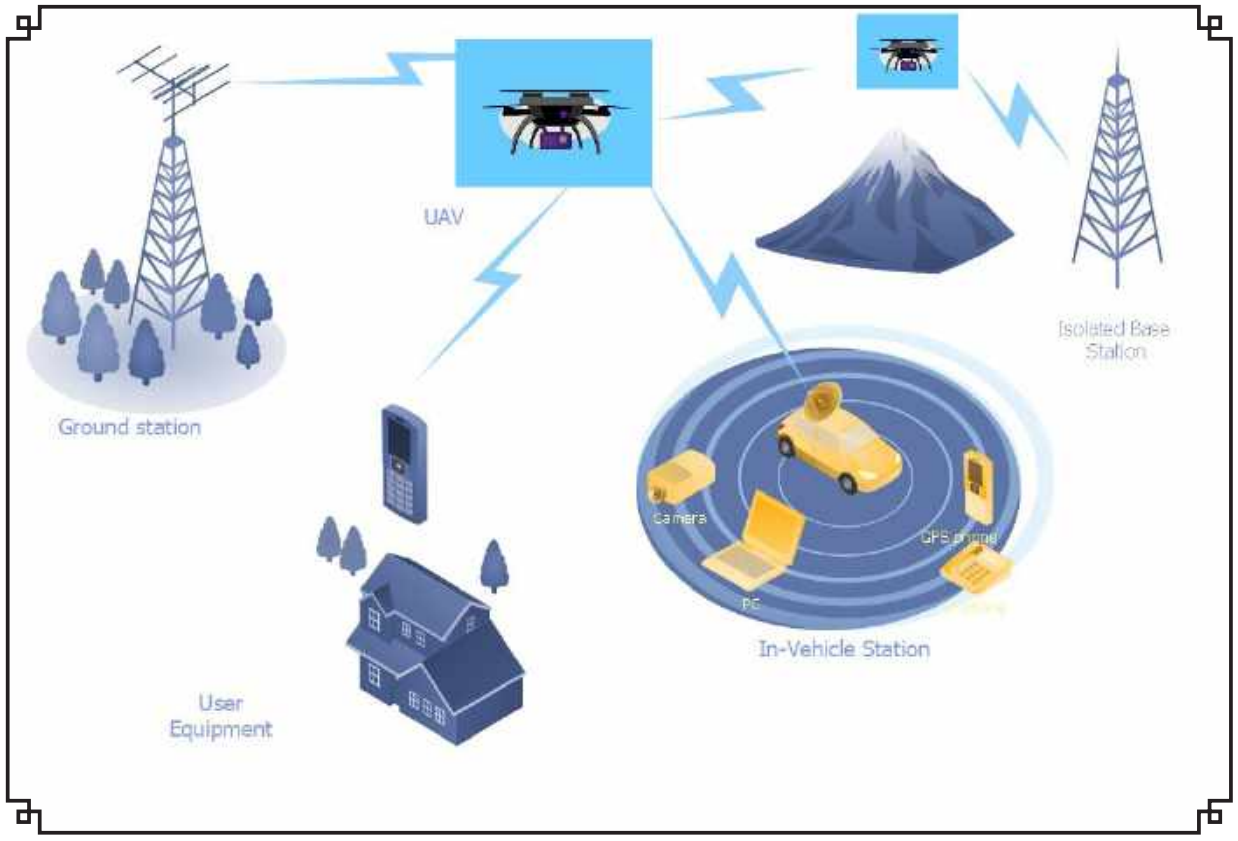

Fig 2 : Cellular connected UAV Communication Network

travel and tourism industries, and some of these types of videos made by vloggers increased foreign tourist attraction to Sri Lanka. However, unfortunately, drones were very recently introduced for these kinds of work in Sri Lanka, and is also growing fast. One of the main reasons for this is that the Sri Lanka's national aviation authority, the Civil Aviation Authority of Sri Lanka (CAASL) has been convinced that commercial drones were safe to be allowed in Sri Lankan air.

Cellular Connected UAV

Imagine a sky with flying vehicles and drones at different attitudes from the ground for which they need wireless connectivity with the ground for different purposes, for controlling the vehicle itself, and for sending mission critical information. In the past few years, many research projects address both high capacity and secure air-to ground connectivity service to the UAV. While telecommunication organizations are currently exploring possibilities for serving UAVs with further cellular network. Because of that drone will be envisioned as one of the key use cases in the future 5G arena. Most researchers in UAV communication field have a dream to use UAV as base stations in future mobile network such as 5G, operating at millimeter wave frequencies, alongside wireless energy transfer. This dream can only come through successful integration of the UAV communication system and the cellular networks. Accordingly, researchers at both academia and industry are currently investigating accurate models for a cellular-connected UAV network using different techniques. Such a proposed model is as shown in figure 2 which depicts a cellular connected UAV communication network.

The use of artificial intelligence techniques in UAV's communication systems will be expanded during the next decade and researchers will more concern about artificial neural networks, deep learning and machine learning techniques to optimize the UAV communication network, as these techniques have shown its predominant advantages in many applications. As an example, researchers at the CTR (Center for Telecommunication Research, Sri Lanka) presented an efficient approach which utilizes the properties of the neural model and the concept of matrix-coloring in order to maximize the UAVs positioning likelihood for optimized throughput coverage and maximum User Equipment (UE) to UAV mapping. Other than that, we have proposed blockchain-based network model to ensure connectivity, availability, and survivability, which are fundamental in achieving ultra-reliable and low-latent communication in UAV communication network. In this research project researcher have evaluated the performance of network model and the proposed approach, in terms of flyby time, probability of connectivity, energy consumption, failure rate, survivability, reliability, and area spectral efficiency. In the other hand, securing UAV communication network is not an easy task because of the difference in communication standards and range of applicability. Aerial nodes are prone to various types of attack in a network such as sybil attack, wormhole attack, sinkhole attack, or impersonation attack. These attacks lead to a large number of vulnerabilities causing fatal incidents. Currently, we are working on introducing novel networking and security architecture for UAV communication system.

To date, researchers in the UAV communication field explored many user cases of cellular connected UAV and has achieved some results. Also, they have been two-sided facing both opportunities and challenges, since both the 5G and UAV fields are still in young age. However, researchers will continue to explore through trial and error, and solve these challenges until the 5G drone become a reality.

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Sustainable Use of Earth Resources

Dr P.B. Dharmasena

A resource is some useful material that we can use to benefit our livelihood. The Earth has many resources that benefit us. Often we refer to these as "Natural Resources". Some of the resources that we use for our benefit are water, air, sunlight, soil, plants, animals, rocks and minerals, as well as fossil fuels (coal, oil, natural gas etc.).

There are two broad categories of Earth's resources namely, renewable resources and nonrenewable resources. Natural resources that can be replaced and reused by nature are termed renewable. Examples are air (wind), fresh water, soil, living organisms (trees) and sunlight. The resources that cannot be replaced are termed nonrenewable. Some examples of non-renewable resources are fossil fuels (coal, oil, and natural gas), diamonds and other precious gems, minerals and types of metals and ores.

Water resource available for the benefit of human beings is much lesser when compared to the total water volume of the globe. It is only 0.03% of the total volume of global water (Fig. 1).

Earth's land surface is only 29%, and the rest comprise the ocean. Of this land surface, the fraction of habitable land surface is 71% (104 mil. km^2), while the rest of it is glaciers and barren lands. Agriculture is practiced in almost half of these habitable lands. Crops are cultivated in a relatively small portion of land (11 mil. km^2), and this is only 2.4% of the Earth surface. Fig. 2 illustrates this land resource distribution over the Earth surface.

The limited land resources is being degraded due to human activities. Land degradation is defined as a negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or value to humans. It is the depletion of its physical, chemical and biological productivity.

It is widely accepted that land degradation is one of the most

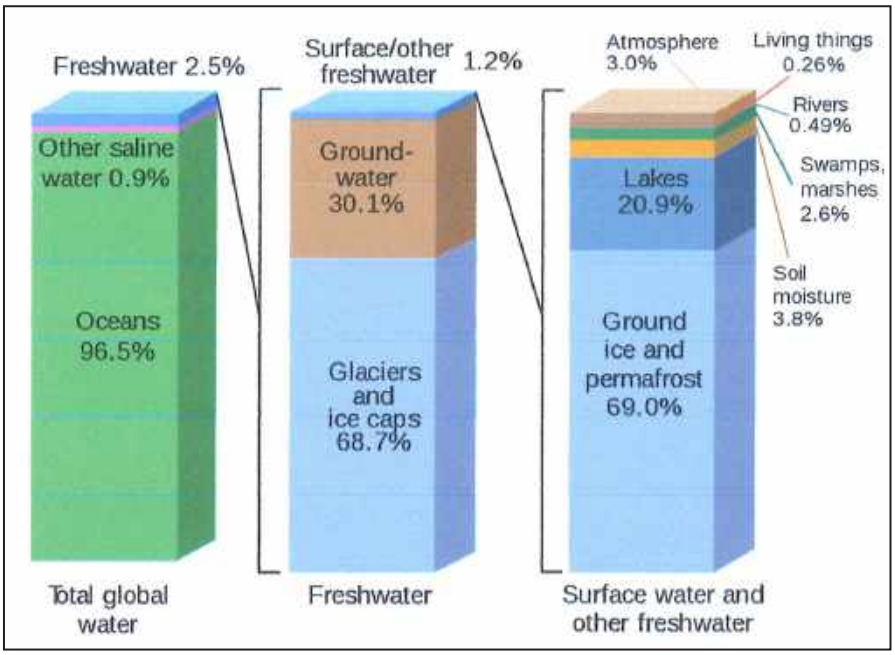

Fig 1 : Distribution of Earth's water resources

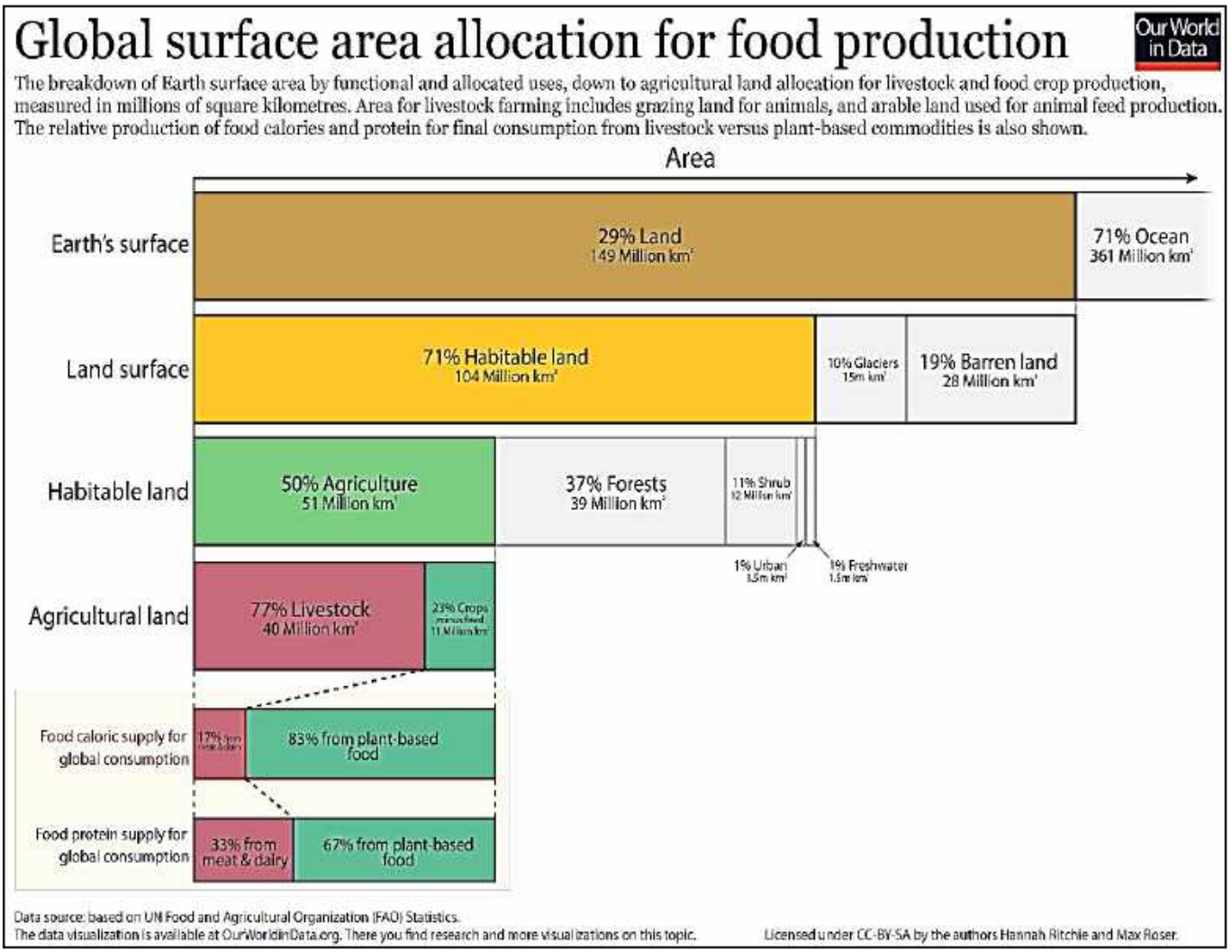

Fig 2 : Distribution of Earth's land resources

critical problems affecting the future economic development in Sri Lanka. The demands of a rapidly expanding population has set up pressures on the island's natural resources, and these in turn have resulted in a high level of environmental degradation. In Sri Lanka most apparent evidence to land degradation is shown in manifestations such as heavy soil losses, high sediment yields, soil fertility decline and reduction in crop yields, marginalization of agricultural land, salinization, landslides and deforestation, as well as forest degradation. Severe soil erosion takes place in the hill country on sloping lands under market gardens (vegetable and potato cultivation), tobacco cultivation, poorly managed seedling tea and chena cultivation. We need to maintain long-term productivity of land, while we use it for our benefit. Sustainable Land management (SLM) has been introduced to cater for this need.

SLM is defined by the World Bank as a knowledge-based procedure that helps to integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet the rising food and fiber demands while sustaining ecosystem services and livelihoods. SLM is necessary to meet the requirements of a growing population. Improper land management can lead to land degradation and a significant reduction in productive and the service functions (biodiversity niches, hydrology, carbon sequestration) of watersheds and landscapes.

The World Overview of Conservation Approaches and Technologies (WOCAT) defines SLM as the use of land resources, including soils, water, animals and plants, for the production of goods to meet the changing human needs, while simultaneously ensuring the long-term productive potential

Fig 3 : Tropical rainforest – Sinharaja in Sri Lanka

of these resources, as well as the maintenance of their environmental functions.

FAO used the definition in UN Earth Summit 1992 as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions".

One similarity among all these definitions is that the land resource includes soil, water, flora and fauna. Therefore, land means the entire ecosystem in a more practical way. It means that 'land degradation is the long-term depletion of the production potential and function of the ecosystem'. Accordingly, sustainable land management is the maintenance of the production potential and functions of an ecosystem.

There are four types of ecosystems in Sri Lanka.

1. Forest and related ecosystems - tropical forest types (Fig. 3), riverine dry forest, grasslands etc.
2. Inland wetland ecosystems - flood plains, swamps, reservoirs, wet villus (Fig. 4)
3. Coastal and marine ecosystems - mangroves (Fig. 5), salt marshes, sand dunes and beaches, lagoons and estuaries, coral reefs
4. Agricultural ecosystems - paddy lands (Fig. 6), fruit cultivations, small crop holdings or other field crops, vegetables, export crop plantations, home gardens, chena lands

Ecosystems provide ample benefits to human beings. In addition to their environmental value, Sri Lanka's varied ecosystems provide many services that are of significant economic value. Despite the fact that all ecosystem services are not marketable, and many pass unrecognized, they play a crucial role in providing goods and services to meet local and national needs.

The most crucial ecosystem services are:

1. Supporting services (that help maintain the conditions for life on earth): Soil formation and retention; nutrient cycling; primary production; pollination; seed disposal; production of O_2; provision of habitats.

2. Regulatory services (i.e. benefits from regulation of ecosystem processes): Air quality maintenance; climate and water regulation; flood and erosion control; water purification; waste treatment; detoxification; human disease control; biological control of agricultural and livestock pests and disease; storm protection.

3. Provisioning processes (i.e. products obtained from ecosystems): Food; wood fuel; fiber; biochemicals; pharmaceuticals and natural medicines; genetic resources; ornamental resources; freshwater; minerals, sand and other non-living resources.

4. Cultural services (i.e. non-material benefits obtained from ecosystems): Cultural diversity and identity; spiritual and religious

Fig 4 : Wet Villu ecosystem in Sri Lanka

values; knowledge systems; educational and aesthetic values; social relations; sense of place; cultural heritage; recreation and ecotourism; communal; symbolic. (Source: Millenium Ecosystem Assessment 2003 Report "People and Ecosystems: A framework for assessment" cited in SCBD, 2003).

Most of the soils in Sri Lanka are highly erodible. Although the problem of soil erosion has been well recognized in Sri Lanka and effective conservation measures have been clearly identified, yet severe land degradation has been taking place in most of the cultivated lands due to absence of attention to soil erosion. There are 3 recommended SLM practices that could be adopted in Sri Lanka.

1.Agronomic practices

• Mulching - conserving moisture, improving the fertility and health of the soil and reducing the weed growth

• Contour planting - decreases negative effects associated with soil erosion such as reducing crop productivity, worsening water quality, flooding, and habitat destruction.

• Zero tillage - increasing the amount of water that infiltrates into the soil, increasing organic matter retention, cycling of nutrients in the soil, reducing or eliminating soil erosion, improving soil biological fertility and making soils more resilient.

• Application of organic fertilizer – made through the natural process of decomposition of organic materials by microorganisms under

Fig 5 : Mangroves in Sri Lanka

controlled conditions. Raw organic materials such as crop residues, animal wastes, green manures, aquatic plants, industrial wastes, city wastes, food garbage etc. enhance their suitability for application to the soil as a fertilizing resource, after composting.

• Mixed cropping - growing of two or more crops simultaneously on the same piece of land. It is also known as multiple cropping. This type of cropping leads to an improvement in the fertility of the soil and increases in crop yield.

2.Vegetative methods

• Biological hedges - Hedges are placed across the slope to slow down the overland flow. These can consist of live or dead materials of biological origin. Alley cropping, graded hedgerows, SALT hedges fall under this category.

• Grass hedges – Here a Grass hedge is established across the slope. Species recommended are Vetiver (*Vetiveria zizanioides*), Citronella (*Cymbopogon nardus*) and Sera (*Cymbopogon citratus*). Pruning has to be done 2-3 times a year and the biomass can be placed as a mulch to the crop.

• Cover crops - Recommended cover crops are *Calopogonium mucunoides* and *Desmodium* species. Maintaining a vegetative ground cover is reported to be beneficial to reduce the incidence of Phtophthora foot rot disease. Growing cover crops is also not widely practiced in Sri Lanka except in rubber and coconut lands

Fig 6 : Paddy ecosystem in Sri Lanka

3.Structural methods

•Lock and Spill drains - This is a hill side ditch unique to Sri Lanka, practiced for soil conservation on sloping lands exceeding 40% slope. The ditch is about 0.6 m wide, 45 cm deep and square in shape, placed across the slope with a slight gradient. Low cross walls of about 45 cm long and 30 cm high are left in the bed of the drain so that it is divided into separate basins of about 4-5 m in length in order to encourage infiltration, and to trap sediment

•Stone bunds – These are used on steep slopes, where soil is not stable enough to keep as risers in terraced lands and where stone is available for such work. The foundation for the stone bund is laid down to 22.5 cm and the bund is raised about 45 cm from the upper side. Generally these bunds are constructed for width of 60 cm.

•Soil bunds and drains – These are adopted on lands with slopes less than 10 %. Bunds are demarcated on sloping lands with simple tools mostly by field extension workers or trained farmers, and the land user is asked to do soil work with or without incentives. This system will reduce the surface flow rate of water.

•Terracing - Converting a steep slope into a series of steps with horizontal or nearly horizontal ledges (shelves), and vertical or almost vertical walls (risers) between the ledges. The wall is vulnerable to erosion and is protected by a vegetation cover and sometimes faced with stones or concrete. There is no channel as such but a storage area is created by sloping the shelf into the hillside. The basic bench system can be modified according to the nature and value of the crops grown.

•Gully control structures - There are varieties of gully control structures from brushwood dams to cement structures. Sometimes you do not find much difference among these structures. The brushwood dam uses small tree branches, packed as tightly as possible across the direction of flow. They can be anchored by packing them between rows of vertical stakes, or by tying down with wire, or stick, laid across the top and fasten down.

Traditional management of natural resources in Sri Lanka has been incorporated into their culture. In ancient times soil, water, animals and plants were their resources which were conserved as an entity for sustainable living. Traditionally they considered 4 resources (sathara sampath) to protect namely forest, water, cattle and child. They followed 10 commandments to secure their lives. It illustrates how they ensured water security, food security, environmental protection, preservation of the knowledge and maintenance of the spiritual strength of their minds. The Ten Commandments, that ensures their whole culture and life are given below.

1. *Diya paththayam thahanchiya* – Regulations for water security during drought
2. *Niyama kanneta govithen bath* – Correct time of cultivation to reduce the risk of crop failure
3. *Gaha kola satha seepawa, Binkare wathurai aubowa* – Sustainability is ensured by plants, animals, land and water
4. *Hithe ispasuwata dan pin karannata peti pas parane hadapan wadapan* – Make your mind free to attend religious events through raising 5 types of babies (child, calf, kitten, pup and chick)
5. *Akahe wehi keten wev amunu puropan* – harvest rainwater and store for future use
6. *Ekathu paadaa nowi hari haman wedak nokaran* – Work as a team
7. *Wee kurahan sambhare atu kotu purawan rale* – Store excess grains for future use (food security)
8. *Thel peni aththan kewumda pangnan* – What is impossible if everything is with you?
9. *Kem pahan denagan sanuhare rekagan* – Gain knowledge to protect all
10. *Kavi sindu ragan hithata kawaddapan* – Preserve the cultural arts

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What have you learnt from the Vidurava 2019 October - December Q4 Issue? Scan your own memory!

Evolution of Artificial Intelligence

True or False?

1. The development of AI has immensely contributed to accelerate the research and development process in many disciplines.

2. Though modern developments in AI tend to promote man – machine co-existence, the gap between man and the machine will be drastically increased day by day.

3. The road map of AI records not only a heap of non-existing developments, but also has loads of misconceptions and criticisms.

4. Human beings claim that they are the most intelligent species of animals by virtue of their power of analytical and logical reasoning.

5. Future development of AI has also been very much influenced by neuroscience concepts such as neuroplasticity and EEG.

Applications of AI at National Level

True or False?

1. A pre-request for leveraging AI at National Level in Sri Lanka, is localized and language processing in and for the national languages of Sinhala and Tamil.
2. Some of the key local language technology applications exclude optical character recognition (OCR) by which printed material in hard copy can be digitized.
3. Biometric analysis is an unrelated application for assisting law enforcement agencies.
4. One of the most topical issues facing Sri Lanka in the recent past has been the fake news phenomenon.
5. A very useful service that currently provides access to government information is the 1919 call centre.

AI in Education – A Problem Based Learning System for Mathematics

True or False?

1. A solution to a problem can be provided with the help of computers, or more specifically with the help of AI.

2. It is important to note that the Maths Tutor is interested to completely remove the teacher from the learning process of the student.

3. When a student submits her answer, it is compared with the system generated answer.

4. Different questions are written down in different formats and are solved in similar ways.

5. The power of this technique is that it can generate questions for any language, given that there is a sample set of similar questions.

AI for Tomorrow

True or False?

1. Today we have very business – specific, or single purpose artificial intelligence known as narrow intelligence.
2. The industry is now adopting AI technologies in order to control pests, maximize harvests, monitor soil and growing conditions, organize data for farmers, predict diseases etc.
3. The rise in the use of information technology in classroom activities in the education sector is not impressive.
4. In the near future we can expect artificially generated intelligence (AGI), a technology that will work across business disciplines.
5. For the scientists, the minor challenge they may face when stepping towards ASP, is establishing and improving the cognitive abilities of AI systems.

The Era of the 5G Drone – Are we Ready

True or False?

1. UAV's have now become very unhelpful in times of distress due to the fact that it is not possible to mount cameras on them.
2. Some of the appilications of UAV's in agriculture include sparying pesticides and other fertilizer to the fields.
3. In a smart city, the city will intercanned all public services using advanced and robust communications technologies.
4. Since planes cannot remain airborne for long periods, and satelites are too than above the Earth's surface. aerial photographers cannot continue to ready an conventional air craft.
5. In the past two years, many research projects addressed both low capacity and insecure air to ground connectivity service to the UAV.

Sustainable Use of Earth Resources

True or False?

1. Water resources available for the benefit of human beings is much less when compared to the total water volume of the globe.
2. It is widely accepted that land degradation is one of the most critical problems affecting the future economic development in Sri Lanka.
3. Despite the fact that all ecosystem services are marketable, and many pass unrecognized, they fail to meet local and national needs.
4. The problem of soil erosion has not been recognized in Sri Lanka and effective conservation measures have not been clearly identified.
5. In ancient times soil, water, animals and plants were the resources of the people, which were conserved as an entity for sustainable living.

Answers

01) 1. True, 2. False, 3. False, 4. True, 5. True
02) 1. True, 2. False, 3. False, 4. True, 5. True
03) 1. True, 2. False, 3. True, 4. False, 5. True
04) 1. False, 2. True, 3. True, 4. True, 5. False
05) 1. False, 2. True, 3. False, 4. True, 5. True
06) 1. True, 2. True, 3. False, 4. False, 5. True

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