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ORIGINAL RESEARCH

Information technologies of 21st century and their impact on the society

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Abstract Twenty first century has witnessed emergence of some ground breaking information technologies that have revolutionised our way of life. The revolution began late in 20th century with the arrival of internet in 1995, which has given rise to methods, tools and gadgets having astonishing applications in all academic disciplines and business sectors. In this article we shall provide a design of a 'spider robot' which may be used for efficient cleaning of deadly viruses. In addition, we shall examine some of the emerging technologies which are causing remarkable breakthroughs and improvements which were inconceivable earlier. In particular we shall look at the technologies and tools associated with the Internet of Things (IoT), Blockchain, Artificial Intelligence, Sensor Networks and Social Media. We shall analyse capabilities and business value of these technologies and tools. As we recognise, most technologies, after completing their commercial journey, are utilised by the business world in physical as well as in the virtual marketing environments. We shall also look at the social impact of some of these technologies and tools.

Keywords Emerging and future technologies · Internet of things · Sensor networks · Location based services · Robotics · Blockchain · Mobile digital platforms

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1 Introduction

Internet, which was started in 1989 [1], now has 1.2 million terabyte data from Google, Amazon, Microsoft and Facebook [2]. It is estimated that the internet contains over four and a half billion websites on the surface web, the deep web, which we know very little about, is at least four hundred times bigger than the surface web [3]. Soon afterwards in 1990, email platform emerged and then many applications. Then we saw a chain of web 2.0 technologies like E-commerce, which started, social media platforms, E-Business, E-Learning, E-government, Cloud Computing and more from 1995 to the early 21st century [4]. Now we have a large number of internet based technologies which have uncountable applications in many domains including business, science and engineering, and healthcare [5]. The impact of these technologies on our personal lives is such that we are compelled to adopt many of them whether we like it or not.

In this article we shall study the nature, usage and capabilities of the emerging and future technologies. Some of these technologies are Big Data Analytics, Internet of Things (IoT), Sensor networks (RFID, Location based Services), Artificial Intelligence (AI), Robotics, Blockchain, Mobile digital Platforms (Digital Streets, towns and villages), Clouds (Fog and Dew) computing, Social Networks and Business, Virtual reality.

2 Big data

With the ever increasing computing power and declining costs of data storage, many government and private organizations are gathering enormous amounts of data. Accumulated data from the years' of acquisition and processing in many organizations has become enormous meaning that it can no longer be analyzed by traditional tools within a reasonable time. Familiar disciplines to create Big data include astronomy, atmospheric science, biology, genomics, nuclear physics, biochemical experiments, medical records, and scientific research. Some of the organizations responsible to create enormous data are Google, Facebook, YouTube, hospitals, proceedings of parliaments, courts, newspapers and magazines, and government departments. Because of its size, analysis of big data is not a straightforward task and often requires advanced methods and techniques. Lack of timely analysis of big data in certain domains may have devastating results and pose threats to societies, nature and echo system.

2.1 Big medic data

Healthcare field is generating big data, which has the potential to surpass other fields when it come to the growth of data. Big Medic data usually refers to considerably bigger pool of health, hospital and treatment records, medical claims of administrative nature, and data from clinical trials, smartphone applications, wearable devices such as RFID and heart beat reading devices, different kinds of social media, and omics-research. In particular omics-research (genomics, proteomics, metabolomics etc.) is leading the charge to the growth of Big data [6, 7]. The challenges in omics-research are data cleaning, normalization, biomolecule identification, data dimensionality reduction, biological contextualization, statistical validation, data storage and handling, sharing and data archiving. Data analytics requirements include several tasks like those of data cleaning, normalization, biomolecule identification, data dimensionality reduction, biological contextualization, statistical validation, data storage and handling, sharing and data archiving. These tasks are required for the Big data in some of the omics datasets like genomics, transcriptomics, proteomics, metabolomics, metagenomics, phenomics [6].

According to [8], in 2011 alone, the data in the United States of America healthcare system amounted to one hundred and fifty Exabyte (One Exabyte = One billion Gigabytes, or 10^{18} Bytes), and is expected soon reach to 10^{21} and later 10^{24}. Some scientist have classified Medical into three categories having (a) large number of samples but small number of parameters; (b) small number of samples and small number of parameters; (c) large small number of samples and small number of parameters [9]. Although the data in the first category may be analyzed by classical methods but it may be incomplete, noisy, and inconsistent, data cleaning. The data in the third category could be big and may require advanced analytics.

2.2 Big data analytics

Big data cannot be analyzed in real time by traditional analytical methods. The analysis of Big data, popularly known as Big Data Analytics, often involves a number of technologies, sophisticated processes and tools as depicted in Fig. 1. Big data can provide smart decision making and business intelligence to the businesses and corporations. Big data unless analyzed is impractical and a burden to the organization. Big data analytics involves mining and extracting useful associations (knowledge discovery) for intelligent decision-making and forecasts. The challenges in Big Data analytics are computational complexities, scalability and visualization of data. Consequently, the information security risk increases with the surge in the amount of data, which is the case in Big Data.

The aim of data analytics has always been knowledge discovery to support smart and timely decision making. With big data, knowledge base becomes widened and sharper to provide greater business intelligence and assist businesses in becoming a leader in the market. Conventional processing paradigm and architecture are inefficient to deal with the large datasets from the Big data. Some of the problems of Big Data are to deal with the size of data sets in Big Data, requiring parallel processing. Some of the recent technologies like Spark, Hadoop, Map Reduce, R, Data Lakes and NoSQL have emerged to provide Big Data analytics. With all these and other data analytics technologies, it is advantageous to invest in designing superior storage systems.

Health data predominantly consists of visual, graphs, audio and video data. Analysing such data to gain meaningful insights and diagnoses may depend on the choice of tools. Medical data has traditionally been scattered in the organization, often not organized properly. What we find usually are medical record keeping systems which consist of heterogeneous data, requiring more efforts to reorganize the data into a common platform. As discussed before, the health profession produces enormous data and so analysing it in an efficient and timely manner can potentially save many lives.

3 Clouds

Commercial operations of Clouds from the company platforms began in the year 1999 [10]. Initially, clouds complemented and empowered outsourcing. At earlier stages, there were some privacy concerns associated with Cloud Computing as the owners of data had to give the custody of their data to the Cloud owners. However, as time passed, with confidence building measures by Cloud owners, the technology became so prevalent that most of the world's SMEs started using it in one or the other form. More information on Cloud Computing can be found in [11, 12].

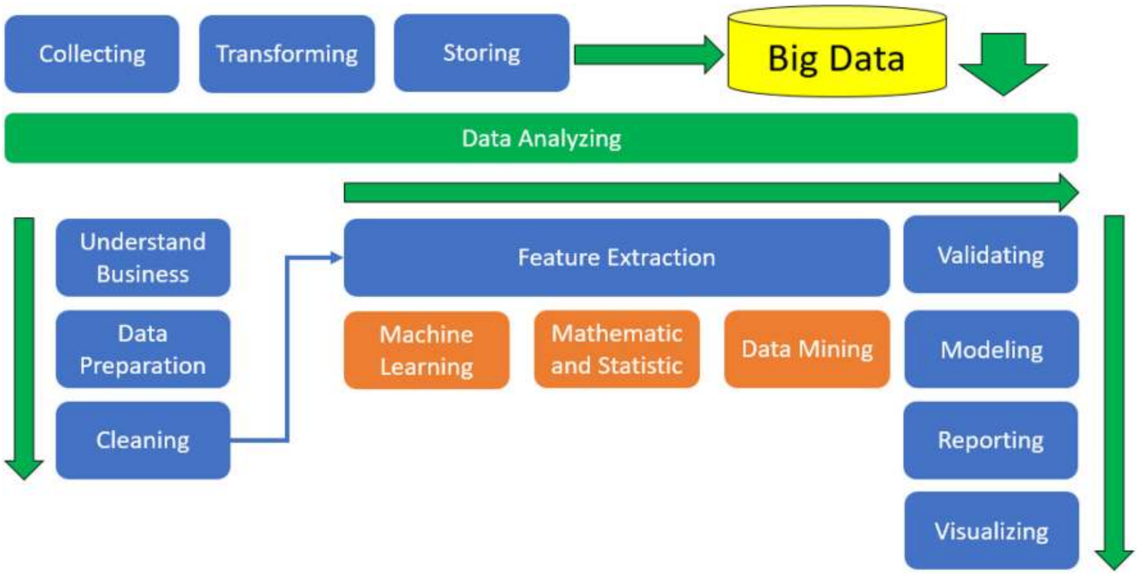

Fig. 1 Big Data Analytics

3.1 Fog computing

As faster processing became the need for some critical applications, the clouds regenerated Fog or Edge computing. As can be seen in Gartner hyper cycles in Figs. 2 and 3, Edge computing, as an emerging technology, has also peaked in 2017–18. As shown in the Cloud Computing architecture in Fig. 4, the middle or second layers of the cloud configuration are represented by the Fog computing. For some applications delay in communication between the computing devices in the field and data in a Cloud (often physically apart by thousands of miles), is detrimental of the time requirements, as it may cause considerable delay in time sensitive applications. For example, processing and storage for early warning of disasters (stampedes, Tsunami, etc.) must be in real time. For these kinds of applications, computing and storing resources should be placed closer to where computing is needed (application areas like digital

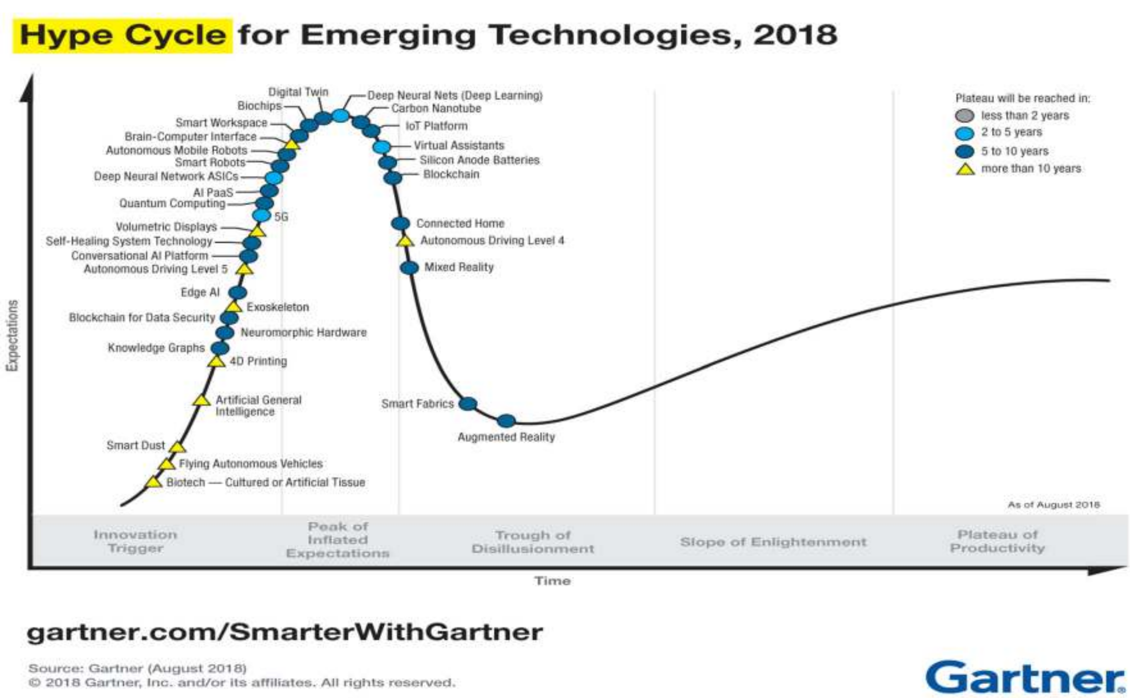

Fig. 2 Emerging Technologies 2018

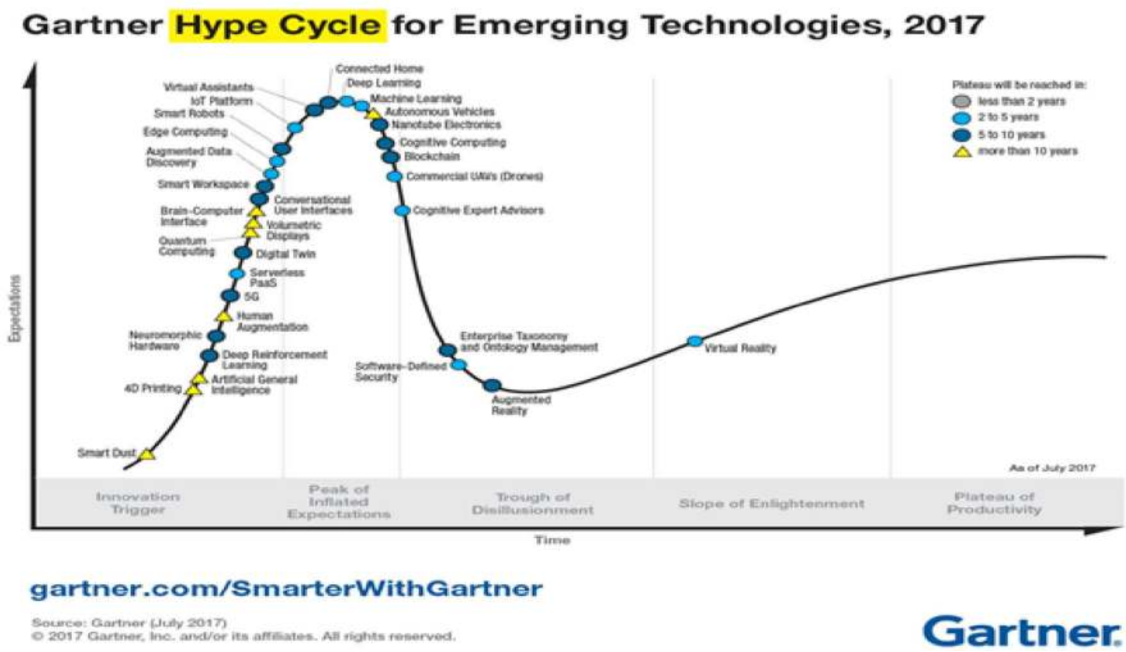

Fig. 3 Emerging Technologies 2017

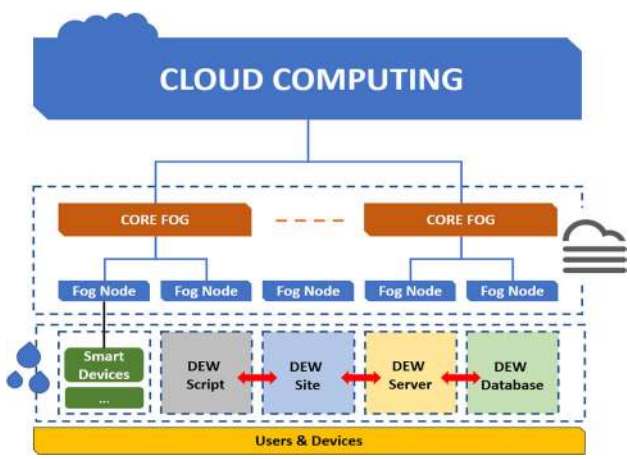

Fig. 4 Relationship of Cloud, Fog and Dew computing

street). In these kind of scenarios Fog computing is considered to be suitable [13]. Clouds are integral part of many IoT applications and play central role on ubiquitous computing systems in health related cases like the one depicted in Fig. 5. Some applications of Fog computing can be found in [14–16]. More results on Fog computing are also available in [17–19].

3.2 Dew computing

When Fog is overloaded and is not able to cater for the peaks of high demand applications, it offloads some of its data and/or processing to the associated cloud. In such a situation, Fog exposes its dependency to a complementary

Fig. 5 Snapshot of a Ubiquitous System

bottom layer of the cloud architectural organisation as shown in the Cloud architecture of Fig. 4. This bottom layer of hierarchical resources organization is known as the Dew layer. The purpose of the Dew layer is to cater for the tasks by exploiting resources near to the end-user with minimum internet access [17, 20]. As a feature, Dew computing takes care of determining as to when to use for its services linking with the different layers of the Cloud architecture. It is also important to note that the Dew computing [20] is associated with the distributed computing hierarchy and is integrated by the Fog computing services, which is also evident in Fig. 4. In summary, Cloud architecture has three layers, first being Cloud, second as Fog and the third Dew.

4 Internet of things

Definition of Internet of Things (IoT), as depicted in Fig. 6, has been changing with the passage of time. With growing number of internet based applications, which use many technologies, devices and tools, one would think, the name of IoT seems to have evolved. Accordingly, things (technologies, devices and tools) used together in internet based applications to generate data to provide assistance and services to the users from anywhere, at any time. The internet can be considered as a uniform technology from any location as it provides the same service of 'connectivity'. The speed and security however are not uniform. The IoT as an emerging technology has peaked during 2017–18 as is evident from Figs. 2 and 3. This technology is expanding at a very fast rate. According to [21–24], the number of IoT devices could be in millions by the year 2021.

IoT is providing some amazing applications in tandem with wearable devices, sensor networks, Fog computing, and other technologies to improve some the critical facets of our lives like healthcare management, service delivery, and business improvements. Some applications of IoT in the field of crowd management are discussed in [14]. Some applications in of IoT in the context of privacy and security are discussed in [15, 16]. Some of the key devices and associated technologies to IoT include RFID Tags [25], Internet, computers, cameras, RFID, Mobile Devices, coloured lights, RFIDs, Sensors, Sensor networks, Drones, Cloud, Fog and Dew.

5 Applications of blockchain

Blockchain is usually associated with Cryptocurrencies like Bitcoin (Currently, there are over one and a half thousand cryptocurrencies and the numbers are still rising). But the Blockchain technology can also be used for many more critical applications of our daily lives. The Blockchain is a distributed ledger technology in the form of a distributed transactional database, secured by cryptography, and governed by a consensus mechanism. A Blockchain is essentially a record of digital events [26]. A block represents a completed transaction or ledger. Subsequent and prior blocks are chained together, displaying the status of the most recent transaction. The role of chain is to provide linkage between records in a chronological order. This chain continues to grow as and when further transactions take place, which are recorded by adding new blocks to the chain. User security and ledger consistency in the Blockchain is provided by Asymmetric cryptography and distributed consensus algorithms. Once a block is created, it cannot be altered or removed. The technology eliminates the need for having a bank statement for verification of the availability of funds or that of a lawyer for certifying the occurrence of an event. The benefits of Blockchain technology are inherited in its characteristics of decentralization, persistency, anonymity and auditability [27, 28].

5.1 Blockchain for business use

Blockchain, being the technology behind Cryptocurrencies, started as an open-source Bitcoin community to allow reliable peer-to-peer financial transactions. Blockchain

Fig. 6 Internet of Things

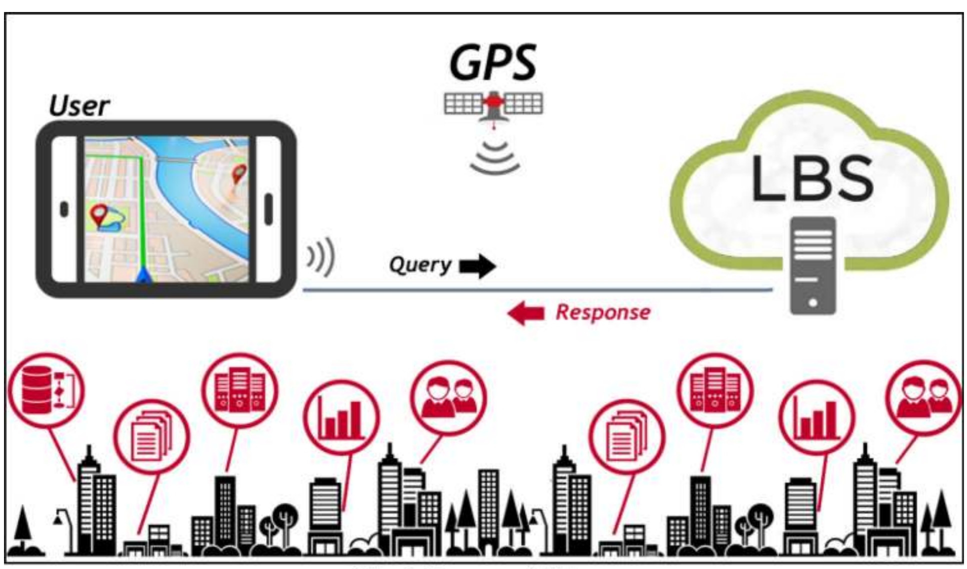

Fig. 6: Internet of Things

technology has made it possible to build a globally functional currency relying on code, without using any bank or third-party platforms [28]. These features have made the Blockchain technology, secure and transparent for business transactions of any kind involving any currencies. In literature, we find many applications of Blockchain. Nowadays, the applications of Blockchain technology involve various kinds of transactions requiring verification and automated system of payments using smart contracts. The concept of Smart Contacts [28] has virtually eliminated the role of intermediaries. This technology is most suitable for businesses requiring high reliability and honesty. Because of its security and transparency features, the technology would benefit businesses trying to attract customers. Blockchain can be used to eliminate the occurrence of fake permits as can be seen in [29].

5.2 Blockchain for healthcare management

As discussed above, Blockchain is an efficient and transparent way of digital record keeping. This feature is highly desirable in efficient healthcare management. Medical field is still undergoing to manage their data efficiently in a digital form. As usual the issues of disparate and non-uniform record storage methods are hampering the digitization, data warehouse and big data analytics, which would allow efficient management and sharing of the data. We learn the magnitude of these problem from examples of such as the target of the National Health Service (NHS) of the United Kingdom to digitize the UK healthcare is by 2023 [30]. These problems lead to inaccuracies of data which can cause many issues in healthcare management, including clinical and administrative errors.

Use of Blockchain in healthcare can bring revolutionary improvements. For example, smart contracts can be used to make it easier for doctors to access patients' data from other organisations. The current consent process often involves bureaucratic processes and is far from being simplified or standardised. This adds to many problems to patients and specialists treating them. The cost associated with the transfer of medical records between different locations can be significant, which can virtually be reduced to zero by using Blockchain. More information on the use of Blockchain in the healthcare data can be found in [30, 31].

6 Environment cleaning robot

One of the ongoing healthcare issue is the eradication of deadly viruses and bacteria from hospitals and healthcare units. Nosocomial infections are a common problem for hospitals and currently they are treated using various techniques [32, 33]. Historically, cleaning the hospital wards and operating rooms with chlorine has been an effective way. On the face of some deadly viruses like EBOLA, HIV Aids, Swine Influenza H1N1, H1N2, various strands of flu, Severe Acute Respiratory Syndrome (SARS) and Middle Eastern Respiratory Syndrome (MERS), there are dangerous implications of using this method [14]. An advanced approach is being used in the USA hospitals, which employs "robots" to purify the space as can be seen in [32, 33]. However, certain problems exist within the limitations of the current "robots". Most of these devices require a human to place them in the infected areas. These devices cannot move effectively (they just revolve around themselves); hence, the UV light will not reach all areas but only a very limited area within the range of the UV light emitter. Finally, the robot itself maybe infected as the light does not reach most of the robot's surfaces. Therefore, there is an emerging need to build a robot that would not require the physical presence of humans to handle it, and could purify the entire room by covering all the room surfaces with UV light while, at the same time, will not be infected itself.

Figure 7 is an overview of the design of a fully motorized spider robot with six legs. This robot supports Wi-Fi connectivity for the purpose of control and be able to move around the room and clean the entire area. The spider design will allow the robot to move in any surface, including climbing steps but most importantly the robot will use its legs to move the UV light emitter as well as clear its body before leaving the room. This substantially reduces the risk of the robot transmitting any infections.

Additionally, the robot will be equipped with a motorized camera allowing the operator to monitor space and stop the process of emitting UV light in case of unpredicted situations. The operator can control the robot via a networked graphical user interface and/or from an augmented reality environment which will utilize technologies such as the Oculus Touch. In more detail, the user will use the oculus rift virtual reality helmet and the oculus touch, as well as hand controllers to remote control the robot. This will provide the user with the vision of the robot in a natural manner. It will also allow the user to control the two front robotic arms of the spider robot via the oculus touch controller, making it easy to do conduct advance movements, simply by move the hands. The physical movements of the human hand will be captured by the sensors of oculus touch and transmitted to the robot. The robot will then use reverse kinematics to translate the actions and position of the human hand to movements of the robotic arm. This technique will also be used during the training phase of the robot, where the human user will teach the robot how to clean various surfaces and then purify itself, simply by moving their hands accordingly.

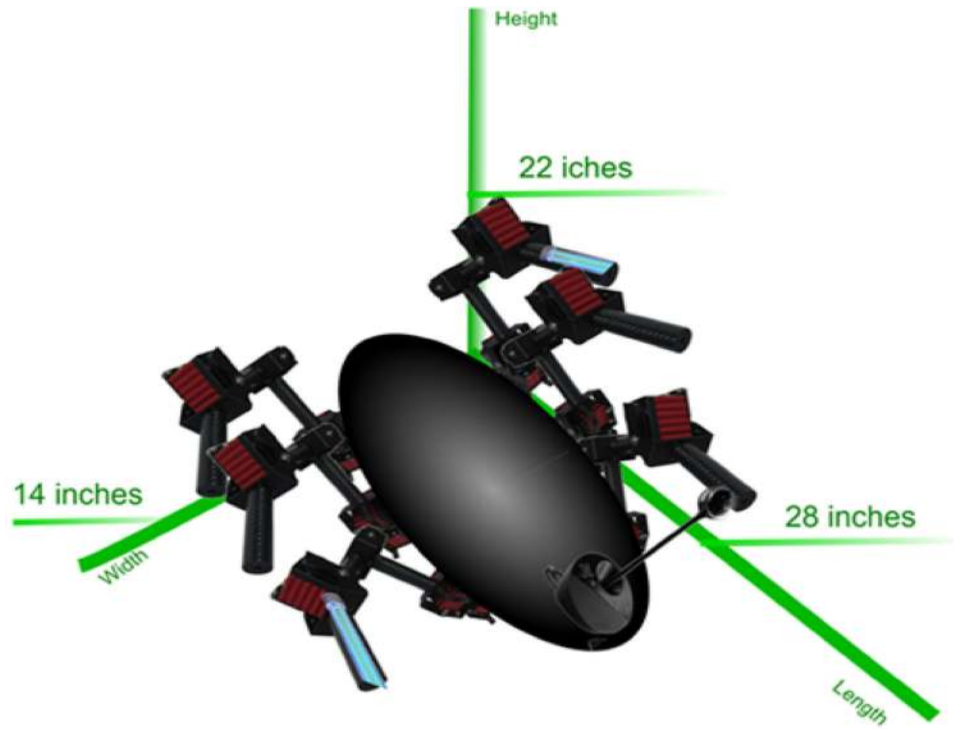

Fig. 7 Spider Robot for virus cleaning

The design of the spider robot was proposed in a project proposal submitted to the King Abdulaziz City of Science and Technology (https://www.kacst.edu.sa/eng/Pages/default.aspx) by the author and George Tsaramirsis (https://www.researchgate.net/profile/George_Tsaramirsis).

7 Conclusions

We have presented details of some of the emerging technologies and real life application, that are providing businesses remarkable opportunities, which were previously unthinkable. Businesses are continuously trying to increase the use of new technologies and tools to improve processes, to benefit their client. The IoT and associated technologies are now able to provide real time and ubiquitous processing to eliminate the need for human surveillance. Similarly, Virtual Reality, Artificial Intelligence robotics are having some remarkable applications in the field of medical surgeries. As discussed, with the help of the technology, we now can predict and mitigate some natural disasters such as stampedes with the help of sensor networks and other associated technologies. Finally, the increase in Big Data Analytics is influencing businesses and government agencies with smarter decision making to achieve targets or expectations.

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