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Emerging Information Technologies in the 21st Century

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ABSTRACT
Engineering and technology play an essential role in the economy of a nation and it had contributed immensely in enhancing and advancing the overall wellbeing of humanity. It is the bedrock for innovation and creativity in entrepreneurship and local content development. This study is aimed at investigating some of the core emerging technologies in information engineering in the twenty first century. In this research work, a concise review of these cutting edge technologies were investigated to aid researchers who are interested in these fields to ascertain how these technologies works: blockchain, the internet of things (IoT), machine learning (ML), big data analytic (BDA), embedded system, mechatronics and robotics, cloud computing, and cyber-physical systems (CPS) are presented along with their respective features with some sample implementation to demonstrate how some of the technology works. This would aid researchers in this area of study.

KEYWORDS: Blockchain**,** internet of things, machine learning, mechatronics, and cyber-physical systems**.**

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1. INTRODUCTION
This research is a collection of studies that is centred on some core area of emerging technologies that thrives on the wings of innovation and creativity. The emerging technology considered in this study are blockchain, internet of things (IoT), machine learning (ML), big data analytic (BDA), embedded system, mechatronics, cloud computing, and cyber-physical systems (CPS). The concept of blockchain was initially introduced in November 2008 and was implemented in January 2009. Blockchain is a chain of blocks interconnected with complex computational crypto algorithms. It is an immutable "distributed ledger technology " (Linn & Koo, n.d., p. 2). It provides a very high level of data security. Another technology widely in use today, is internet of things. The availability and miniaturization of electronic devices has enhanced embedded system to work with sensors and machinery to enable IoT technology in many devices/appliances**.** In this context, IoT is a network of connected devices that can automatically collect and send data over various networks without human involvement. IoT allows things to interact with their internal and/or external environments, allowing them to make decisions. The devices rely on the internet using various communication types and data collected can be shared between other applications to help improve user experience. It was forecasted that IOT would connect over 30 billion devices by 2025 (Lund *et al.*, 2014)

Another emerging technology **is** Machine Learning, it is a system that enable machine to acquire good level of intelligence from data collected over a period of time. This acquired knowledge enable the system to make accurate decisions with little or no human intervention. The system learn pattern from the collected data to make quality decisions in the future, without manual inputs.

ML is a process of using data and statistics to train it to act intelligently. It is a program that can forecast the possible outcomes of a process from the analyzed data. Machine learning is a branch of artificial intelligence that aims at enabling machines to perform their jobs skillfully by using intelligent software (Mohammed *et al.*, 2016). Another is Big Data Analytics, this technology provides the process of collecting, organising and analysing huge sets of data in other to obtain useful information or discover useful trends. It can help to give better understanding of all the data that was generated or received from the IoT network and identify the most important data for the task at hand. Big Data analytics (BDA) has been identified as a critical technology to support data acquisition, storage, and analytics in data management systems in modern manufacturing (Bi & Cochran, 2014).

Embedded Systems is a popular technology, it is a system that consist of computer hardware, operating system and the application software that runs on it. Embedded Systems is a subset of Electrical Engineering, Information Technology, and Mechatronics (Alippi, 2014). Another trending technology is Mechatronics and Robotics, it is a study that mimic human behavour in handling different types of responsibilities. The system is developed to be intelligent to carry out its task at the right time without human instructions or control. The mechatronic design is an iterative and integrated process that includes different kinds of the domain-specific engineering for successful design, implementation, and inspecting`(Luo & Perng, 2011). Another widely used technology is Cloud Computing. It involves delivering applications and services on demand over the internet. Facilities like, infrastructure, software, application platform, databases, storage resources and many more are provided on demand and are metered services to the users, in a “pay as you go” manner. Mobile Cloud Computing merges the cloud computing technologies with mobile devices to overcome the limitations of these devices (Tawalbeh *et al.*, 2015). Finally, Cyber-Physical Systems (CPS) uses computer-based algorithms to monitor or control machines/devices. It is a new generation of systems with integrated computational and physical capabilities that can interact with humans through many new modalities (Samad & Annaswamy, 2011). It is expected to play a major role in the design and development of future engineering systems with new capabilities. The technology is prevalently from the industrial sector and serves as the engine of innovation for a new era of end user products.

2.0 MATERIALS AND METHODS

2.1 Blockchain Technology

One of the key strengths of blockchain is "hashing." Each block has information to be stored, and every new block added in the chain is encoded with a "hash," a code arithmetically produced and generated from the block's date. Moreover, each newly added block includes the hash of the preceding block in the same block hash. In this way, falsifying new or old blocks becomes very difficult. Hashes of previous blocks determine the hashes of subsequent blocks; therefore, altering a single block would require rewriting the entire blockchain. This mechanism of linking the blocks into a chain makes tampering extremely difficult (Hughes & Morrow, 2019; White, 2017). Hence, the use of blockchain would enhance data security and therefore, efficiently and effectively manage data confidentiality, integrity, availability and other vital transactions of the system.

This technology can be applied in the following fields: IOT, energy, healthcare, accounting, insurance, supply chain management, advertising and media, legal, real estate, and finance (Baiod *et al.*, 2021).

2.2 Internet of Things (IoT)

Presently, the increase in demand of service over the internet have created the need to collect and exchange data in an efficient manner (Wadhwani *et al.*, 2018). This was achieved with the solution IoT provides. IoT describes the network of physical objects, that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. **IoT** is the network of physical objects that can exchange data for value. Some application domains of IoT technology include home automation (smart lighting, smart appliances, intrusion detection, smoke/gas detectors), cities (smart parking, smart lighting, smart roads and internet connected cars, structural health monitoring, surveillance, emergency response), environment (weather monitoring, air pollution monitoring, noise pollution monitoring, forest fire detection, river flood detection), energy (smart grids, renewable energy systems, prognostics), retail (inventory management, smart payments, smart vending machines), logistics (route generation & scheduling, fleet tracking, shipment monitoring, remote vehicle diagnostics), agriculture (smart irrigation, green house control), industry (machine diagnosis and prognosis, indoor air quality monitoring), health & life style (wearable devices, smartphones, non-surgical robots connected to the IoT, IoT devices), etc.

2.3 Machine Learning (ML)

Prior to machine learning, we had expert system that depend on knowledge engine that require domain experts who provide the required knowledge experience to feeds the knowledge engine with accurate information. However, ML is now, taking over expert systems because machines can learn on its own without inputs from the domain experts. To make the world and its physical objects autonomous, we need a machine learning (ML) system that emulates human learning, as well as a data analysis (DA) module. ML creates techniques that facilitate learning in various components/devices of the network to make them automatic and self-standing, whereas DA would evaluate/analyse all the data that is generated over time to find out the past trends so as to be more efficient and effective in future. This trend has been growing and now efforts are being made to incorporate ML and DA into sensors and embedded systems of the smart systems. The technology behind AI is really intriguing. *ML also solves problems that cannot be solved by numerical means alone.* Among the different types of ML tasks listed below, a crucial distinction is drawn between supervised and unsupervised learning:

i. **Supervised machine learning:** The program is "trained" on a pre-defined set of "training examples", which then facilitate its ability to reach an accurate conclusion when given new data.
ii. **Unsupervised machine learning:** The program is given a bunch of data and must find patterns and relationships therein.
iii. **Reinforcement Learning**. How software agents should take actions in an environment in order to maximize the notion of cumulative reward.

The best of machine learning programming languages among others are Python, R programming, Java and Java script. Ten machine learning methods that researchers in this field should know are:

i. Regression
ii. Classification

iii. Clustering
iv. Dimensionality Reduction: usually time-series problem.
v. Ensemble Methods
vi. Neural Nets and Deep Learning
vii. Transfer Learning
viii. Reinforcement Learning
ix. Natural language processing
x. Word embeddings

2.4 Big Data Analytic (BDA)

BDA is the process of collecting, organizing and analysing large sets of data (Duan and Xu, 2021) called big data, generated over time to find patterns and other useful information and be more efficient/effective in future. IoT generate huge amount of data with varying content types that are processed and analysed over time using BDA to make the system better. Usually, machine learning algorithms are modified and adapted to handle the 'Big Data' scenario. Today, there are millions of data sources that generate data at a very rapid rate. These data sources are present across the world. Some of the largest sources of data are social media platforms and networks (Simplilearn, 2021).

Take the music streaming platform 'Spotify' for example. The company has nearly 96 million users that generate a tremendous amount of data every day. Through this information, the cloud-based platform automatically generates suggested songs through a smart recommendation engine based on likes, shares, search history, and more. What enables this is the techniques, tools, and frameworks that are a result of big data analytics (Simplilearn, 2021). Big Data is actively used in ecommerce, marketing, education, healthcare, telecommunications, media and entertainment, banking, and government.

The benefits and advantages of Big Data Analytics are firstly, for risk management, the banking industry use it to identify fraudulent activities and discrepancies. Secondly, for product development and innovations, manufacturers of jet engines use it to analyze how efficient the engine designs are and if there is any need for improvements. Thirdly, for quicker and better decision making within Organizations, and lastly, to Improve customer experience, airline companies monitor tweets to find out their customers' experience regarding their journeys, delays, and so on. It helps the airline build good customer relations.

2.4.1 The Lifecycle Phases of Big Data Analytics

Phase I: Business case evaluation - The big data analytics lifecycle begins with a business case, which defines the reason and goal behind the analysis.
Phase II: Identification of data - Here, a broad variety of data sources are identified.
Phase III: Data filtering - All the identified data from the previous stage is filtered here to remove corrupt data.
Phase IV: Data extraction - Data that is not compatible with the tool is extracted and then transformed into a compatible form.
Phase V: Data aggregation - In this stage, data with the same fields across different datasets are integrated.
Phase VI: Data analysis - Data is evaluated using analytical and statistical tools to discover useful information.
Phase VII: Visualization of data - With tools like Tableau, Power BI, and QlikView, Big Data analysts can produce graphic visualizations of the analysis.
Phase VIII: Final analysis result - This is the last step of the Big Data analytics lifecycle, where the final results of the analysis are made available to business stakeholders who will take action.

2.5 Embedded System

Embedded System is a combination of computer hardware and software designed for a specific function: It is something that is attached to another thing. It can be an independent system or a part of a large system. An embedded system is a

microcontroller or microprocessor-based system which is designed to perform a specific task. The gadgets/devices that constitute a CPS would contain embedded systems, like camera, temperature measure, etc. Each device would have different embedded systems or sensors as per their requirements. below are some of the widely used embedded system/ microcontrollers.

Raspberry Pi: is basically a series of very small single board computers, which actually have additional features as Bluetooth, Wi-Fi, USB capabilities, general input & output ports etc. Basically it is a small low cost credit card computer, which can be plugged to monitor as well as keyboard & mouse. It is a combination of Raspberry operating system and python programming language. Raspberry Pi Hardware: Processor, RAM, Peripherals, Networking, Video, Connectors.

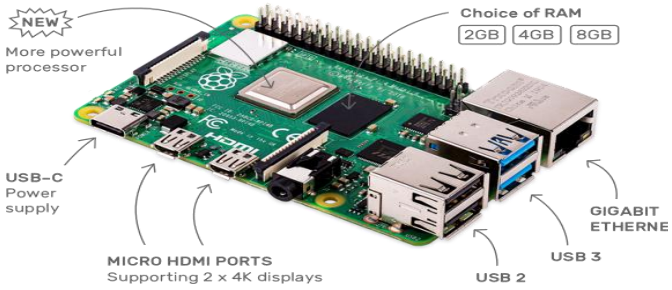

Plate 1: Raspberry Pi 4 Model

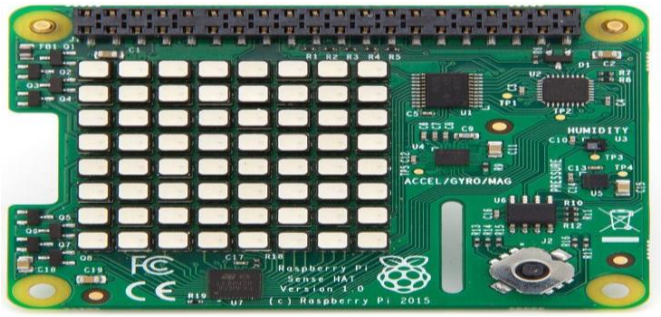

Plate 2: Raspberry Pi Sense HAT

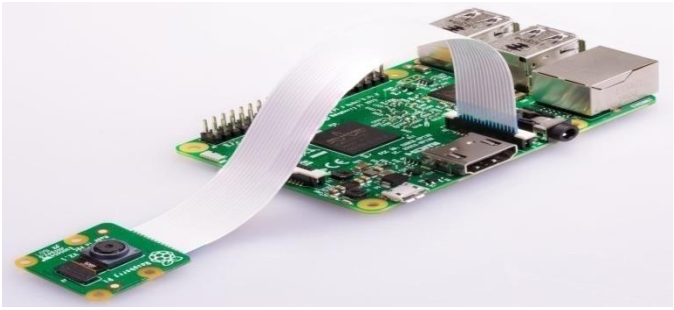

Plate 3: Raspberry Camera

Arduino refers to an open-source electronics platform or board and the software used to program it. They are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online (Taufiq & Zanuar, 2020).

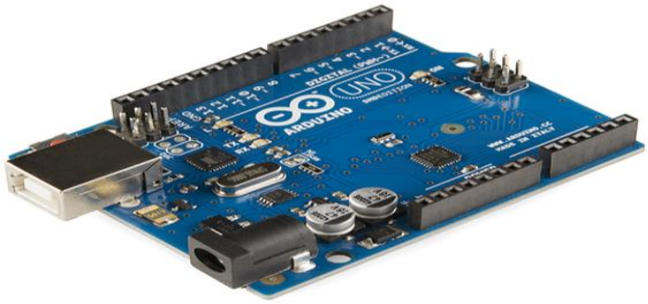

Plate 4: Arduino Board

2.5.1 Arduino Vs Raspberry

Arduino is a single-board microcontroller does not support audio and GUIs, Arduino specific IDE and compiler, uses 'shields' for extending functionalities, best at controlling machines and performing repetitive tasks. However, raspberry is a single-board computer, supports audio and GUIs, wide range of operating software, Uses 'Hats' for extending functionalities, best at logical processing and communicating with other systems.

2.6 Mechatronics

Mechatronics is the combination of mechanical, electrical and computer engineering in the design of products and manufacturing processes. Most modern products like automobiles, household appliances, printers, hard-disk drives, surgical tools, and lots more embodies numerous smart features enabled by mechatronics. Its design strives to produce higher performance at lower costs, this is a critical goal in the engineering sector in today's economy. Robotics is a subset of mechatronics. All robots are mechatronic; however, they are an elevated class of mechatronics, incorporating automation, programming, and even autonomous action.

Areas of Specialties

i. Nanomanipulation and nano manufacturing
ii. Robotics
iii. Smart materials and structures
iv. Structural health monitoring
v. Haptic interface and robotics
vi. Production and application of nanostructured materials
vii. Kinematics and synthesis of mechanisms
viii. Human-robot interactions
ix. Networked multi-agent systems

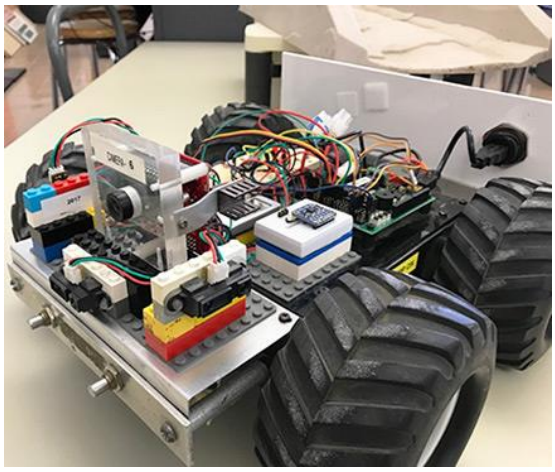

Plate 5. Sample Mechatronic design

2.7 Cloud Computing

Cloud Computing came into existence to solve or overcome the challenges organizations are faced with in setting up IT infrastructure and to reduce its cost. The term cloud refers to a network or the internet. It is a technology that uses remote servers on the internet to store, manage, and access data online rather than local drives. The data can be anything such as files, images, documents, audio, video, and more (Javatpoint, n.d.). Some things that can be done using cloud computing are firstly, It provides a platform where new applications and services can be developed, secondly, It is a platform that is used for storing, backing up, and recovering data, thirdly, we can host blogs and websites with it, fourthly, we can deliver software on demand, fiftly, we can conduct data analysis, and lastly, we can streaming videos and audios.

The characteristics of cloud computing are given below:

i) Agility: The cloud works in a distributed computing environment. It shares resources among users and works very fast.

ii) High availability and reliability: The availability of servers is high and more reliable because the chances of infrastructure failure are minimum.

iii) High Scalability: Cloud offers "on-demand" provisioning of resources on a large scale, without having engineers for peak loads.

iv) Multi-Sharing: With the help of cloud computing, multiple users and applications can work more efficiently with cost reductions by sharing common infrastructure.

v) Device and Location Independence: Cloud computing enables the users to access systems using a web browser regardless of their location or what device they use e.g. PC, mobile phone, etc. As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere.

vi) Maintenance: Maintenance of cloud computing applications is easier since they do not need to be installed on each user's computer and can be accessed from different places. So, it reduces the cost also.
vii) Low Cost: By using cloud computing, the cost will be reduced because to take the services of cloud computing, IT company need not to set its own infrastructure and pay-as-per usage of resources.
viii) Services in the pay-per-use mode: Application Programming Interfaces (APIs) are provided to the users so that they can access services on the cloud by using these APIs and pay the charges as per the usage of services.

2.8 Cyber-Physical System (CPS)

The term "Cyber-Physical Systems (CPS)" emerged around 2006, when Helen Gill at the National Science Foundation in the United States coined it. CPS according to National Science Foundation (NSF) are "engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components". Today it is thought of as a system that works on and is monitored by computer-based mechanisms (built inside each component as well as in the complete system), strongly connected via the Internet and is easily accessible to its users.

CPS are emerging from the integration of embedded computing devices, smart objects, people, and physical environments, which are typically tied by a communication infrastructure. So, the design of CPS and the implementation of their applications need to rely on IoT enabled architectures and protocols that, both locally and globally, enable collecting, managing, and processing large data sets and support complex processes to manage and control such systems. Thus, as a matter of fact, the large-scale nature of IoT-based CPS can be effectively and efficiently facilitated and supported via utilizing the cloud computing infrastructures and platforms for providing flexible computational power, resource virtualization, and high-capacity storage for data streams in addition to ensuring safety, security, and privacy (Tan *at al.*, 2018).

3.0 RESULTS AND DISCUSSION

3.1 Blockchain

Blockchain has demonstrated its potential for facilitating complex processes such as transaction verification, reconciliation and settlement, and dispute resolution through its design features as summarized in table 1.

Table 1: Blockchain Potentials

Area of Application	Blockchain Outcome
IoT	Enhances IoT security and privacy in interconnected devices
Energy	improve security and privacy in smart grids energy trading by allowing the use of digital currencies.
Healthcare	Helps patients to manage their medical information and enforces security when sharing medical information.
Real estate	Reduces fraud, improved secure transaction, eliminates processing fees or commissions, helps investors trace the history and establish trusted and transparent real estate system
Legal	Speed up the execution of legal agreements and build trust in online legal services
Advertising and media	Provides cost-effective online advertising, reduces fraud, boast transparency in the media industry, ensure content security and copyrights.

Area of Application	Blockchain Outcome
Supply chain management	Improved visibility, transparency, accountability in supply chain systems and logistics management.
Accounting	Eliminates reconciliations, provides a complete audit trail and reduces cost, errors and fraud.
Insurance	Enable a transparent insurance marketplace and eliminates fraud
Finance	Facilitates fast, secure, low-cost payment processing services without intermediaries and provides digital stock trading without involving a third party.

3.2 Home Automation Using IoT enabled Devices

The simulation screen capture shown in figure 1 is a prototype design of a smart home. It shows that the IP based IoT devices: Fan, Light, Motion detector, AC, webcam and doors were properly configured to provide network connection to the entire Home Infrastructure. The connecting lines indicates wireless connection between the home gateway, internet and other devices. Furthermore, the integrated service routers/access points (home gateway) create a point of presence (POP) wireless network connection between IoT devices in the Home and other devices with WiFi enabled technologies. The user smartphone is configured to control and manage the home appliances from any location through the internet. After logging in with the smartphone, the user sees all the devices in home listed and from there it can all be controlled (see Fig 1 and Fig 2).

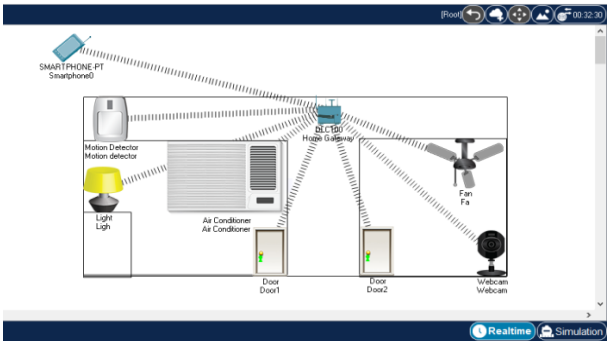

Fig 1: view of wireless connected IoT devices

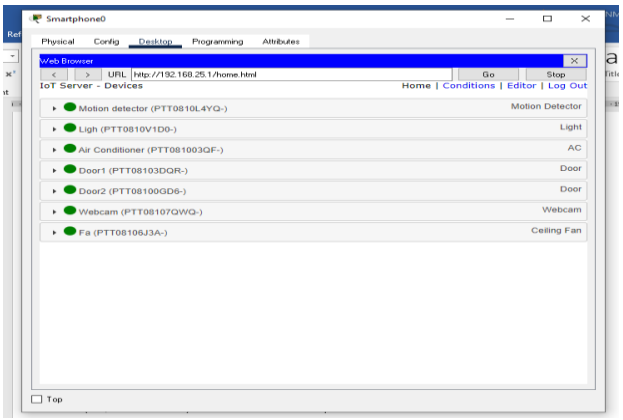

Fig 2: view of web access to wireless connected IoT devices

3.3 Sample Implementation of ML

Table 3.1 shows some sample data for the age and speed of cars that were recorded and to be analysed to be able to predict the speed of a car at any given age using linear regression method of machine learning.

Table 2: Age and Speed of Cars

Car Age	Car Speed
7	104
9	91
10	92
9	93
4	116
19	91
4	108
11	92
6	99

Car Age	Car Speed
13	83
14	82
11	90
8	91

Below is a sample program written in python to Predict the speed of a 12 year old car:

```
import matplotlib.pyplot as plt

from scipy import stats
car_age = [7,9,10,9,4,19,4,11,6,13,14,11,8]
car_speed =
[104,95,92,94,116,81,108,92,99,83,82,90,91]
slope, intercept, r, p, std_err =
stats.linregress(car_age, car_speed)
def ml_focast(car_age):
  speed = slope * car_age + intercept
return speed
speed = ml_focast (12)
print(speed)

mymodel = list (map(ml_focast, car_age))

plt.scatter(car_age, car_speed)
plt.plot(car_age, mymodel)
plt.show()
```

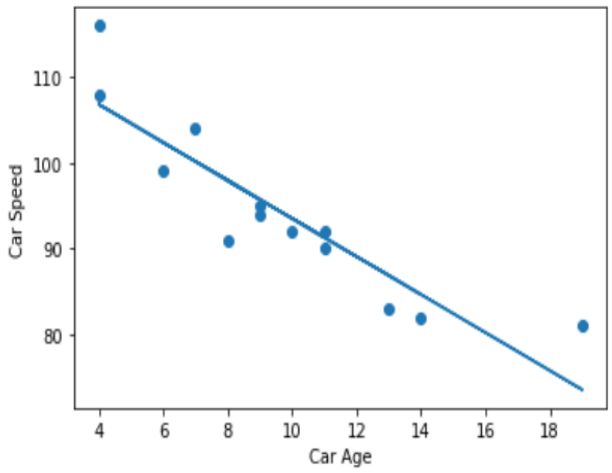

Fig. 3: Graph of Age of car and speed of car

The graph in fig 3 is a plot of the age and speed of cars. the result show that the speed of the car reduces as the car ages, and also the obtained linear regression equation to predict the speed of a car at any age using the global format (y = mx+c) is car_speed = -2.215 car_age + 115.68 with a coefficient of correlation r = -0.8983.

4.0 CONCLUSION

This research had explored some of the leading-edge technologies that will empower entrepreneurs to acquire the relevant information and skills necessary to make them succeed in their entrepreneurship goals and also enhance the development of local content inventions and creativity that would boast the nation's economy. In addition, some specific emerging technologies were considered including technologies that are widely in used in modern times. This would aid researchers who are interested in these fields to ascertain how these technologies works: blockchain, internet of things (IoT), machine learning (ML), big data analytic (BDA), embedded system, mechatronics and robotics, cloud computing, and the cyber-physical systems (CPS) were presented along with their respective features and some sample implementation to demonstrate how the technology works, so as to aid researches develop their research in these area of study.

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