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Smart Agriculture in Nigeria With Iot; A Reality

[1]Arthur Ume, [2]Usman DahiruHaruna
[ModibboAdama University of Technology, MAUTECH Yola-Adamawa State, Nigeria]
[ModibboAdama University of Technology, MAUTECH Yola-Adamawa State, Nigeria]
Corresponding Author: [1]Arthur Ume

Abstract: *This paper presentation indicates that the adoption of smart agriculture should no longer be regarded as hype but reality in Nigeria. The paper posits that ICTs and the innovative surround technologies which enable connectedness of devices in smart agriculture have since penetrated Nigeria's industrial and living space. In the paper, the authors briefly discussed these technologies,namely:Internet of Things (IoT); Big Data & Big Data Analytics; Remote Sensing & RFID; Machine Learning Engine – Artificial Intelligence; Geo-Positioning Systems (GPS); Robotics & Cloud Robotics.* ***The paper then went ahead to narrate related breakthroughs on successful introduction of smart agriculture, using some of these technologies. It concluded by arguing and reasoning thatthe possiblesolution to the present land-use pressure and fast depleting agro-hydro-ecological-potential plaguing many parts of Nigeria could be found in the successful adoption of smart agriculture, - smart cattle rearing, smart soil mapping and smart management of the country's ecological/water expanses.***

Keywords*: Smart farming, Internet of Things, Big Data & Big Data Analytics, Remote Sensing & RFID,Automatic Identification and Data Capture, Machine Learning Engine,Artificial Intelligence, Geo-Positioning Systems, Robotics & Cloud Robotics, Agro-hydro-ecological-potential, ICTs.*

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I. INTRODUCTION

Not too long ago, the World witnessed a great agricultural boom as a result of innovations and breakthroughs in genetics, and the Genome project. Once again, another boom can be seen in the horizon as a result of possibilities to leverage huge improvements in ICT, specifically IoT applications and solutions which are increasingly being introduced as key innovations in Geo-positioning systems, Big Data, UAVs (Unmanned Aerial Vehicles, drones), remote sensing and robotics. These technologiesare increasingly coming into the production space and practical use, and when "cemented together" by IoT (Internet of Things) constitute a potent force that many researchers believe, will be driving the envisaged boom. This new wave of technology innovations and capabilities is sureushering a Third Green Revolution into the Agricultural sector.It is worth knowing that the practical application and leveraging of the afore-mentioned technologies and innovations by farmers is what has been coined as "*smart farming*". In other words, smart farming is the extensive use of integrated ICTs for agricultural endeavours and purposes. This is no more a hype, but has become a reality not only in the more developed economies but also in developing countries like Nigeria, where the use of Information and Communication Technologies (ICTs) had been on an exponential increase for the last two decades. It is therefore no wonder that many scholars and IT experts opine that "IoT, Big data and Smart farming are the future of the World's agriculture" In this paper the authors discuss the key surround technologies that made the advent of Smart Agriculture possible. The paper first outlines and briefly discusses these enablingsurround technologies.

Briefs On Iot& Its Surround Technologies That Enable Smart Agriculture

Internet Of Things (Iot); Adoption And Penetration In Enterprise Computing.

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist fire-fighters in search and rescue operations. These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. Many authors like (Rouse, n.d. para. 1), define "The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction". They say that "a thing, in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low -- or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network". This definition and many others try to capture the exact meaning and essence of IoT.sently, there are ongoing concerted efforts to educate everyone on the fact that IoT is no longer a buzz word; it has become a reality, and it is high time people inside the tech industry or ICT related field embraced this fact. Researchers and scholars are beginning to also echo this fact all over the world. For example, currently, innovators at the SAM Labs in London are going the extra mile to provide an easy to learn programming platform and tools to let people become independently innovative and creative by learning how to program for IoT without necessarily a diploma or higher degree in software engineering or computer science. SAM Labs presently offers a range of development kits that offer widget-like buttons; LED light, motor, slider and a buzzer that would enable ordinary users connect third-party compnents together to create simple solutions and devices that are used to solve simple needs.

1.1 Big Data& Big Data Analytics

Big data is an emerging paradigm applied to datasets whose size or complexity is beyond the ability of commonly used computer software and hardware tools. Such datasets are often from various sources (Variety) yet unstructured such as social media, sensors, scientific applications, surveillance, video and image archives, Internet texts and documents, Internet search indexing, medical records, business transactions and web logs; and are of large size (Volume) with fast data in/out (Velocity). More importantly, big data has to be of high value (Value) and establish trust in it for business decision making (Veracity).Millions of chips and sensors as well as human inputs from smartphones or tabletsor PDAs do generate vast and huge amounts of data. When these amounts of generated data is combined with existing sources of data…from legacy databases and records extending back decades, one suddenly understands the new frontier of data that exists, and the fact that this volume of data exponentially balloons every year. It is no wonder that Researchers and software engineers at the International Data Corporation predict that by 2020, *40 zettabytes*[1]of data will exist worldwide. Actually, the coming of IoTadditionally increased the number of data sources along with the volume, velocity, veracity and variety of data. Data scientists are now not only expected to worry about data collected and generated by personal laptops and desk computers in legacy systems' environment, they are also faced with the task of managing huge streams of data coming from devices which are integrated intoIoT; such additional streams of data come from satellites, parking meters, vending machines, television sets, point-of-sale terminals, gas pumps, food packages, household appliances, light switches, restrooms, and supermarket shelves, etc. This is the concept of Big Data encompasses.Many data scientists and researchers define Big Data as "The use of large and broad data sets along with analytics to understand events, trends and activities in much deeper and useful ways". Big data is high-volume and high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation." Big Data analytics find insights that help organizations make better business decisions. imply speaking, *Big Data* is the concept that centers on collecting, tracking storing, and using datasets generated from both structured data (i.e. data which resides in conventional databases), and unstructured data (i.e. data which exists outside of conventional databases), typically these are in the form of messaging streams, text, documents, photos, video images, audio files, and social media.The daunting challenge, moving forward, is to identify the right data and put datasets to use effectively. any scholars and writers are rightly saying that as the digital age and ubiquity continue to pervade, the term "big data" is actually taking the center stage of the ensuing IoT universe.t is therefore no wonder that Microsoft in this quest to is rapidly expanding its Windows Azure around the globe. In Australia for example, they have sited two new and huge datacentres in Sidney and Melbourne; presently they are already offering services in Japan, Tokyo and China. This is all in anticipation of the "tsunami-like" revolution which IoT will be ushering in the next few years

1.2 Remote Sensing &RFID

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[1]NB**:** 1,000 terabytes equals 1 petabyte; 1,000 petabytes equals 1 exabyte; and 1,000 exabytes equals 1zettabyte. A single zettabyte would total about 250 billion DVDs by comparison.

Remote sensing usually involves Automatic Identification and Data Capture (AIDC). AIDC simply refers to the methods used to automatically identify objects or devices, capture, collect and track data about their attributes, possibly with the help of a computer system. Such methods include use magnetic stripes, use of smart cards and Radio Frequency Identification (RFID). RFID is relatively a new technology, andit is presently used by designers extensively for remote sensing.Actually, the concept of the Internet of Things first became popular in 1999, through the Auto-ID Center at MIT and related market-analysis publications. Radio-frequency identification (RFID) was seen as a prerequisite for the IoT at that point. If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them. Besides using RFID, the tagging of things may be achieved through such technologies as near field communication, barcodes, QR codes, Bluetooth, and digital watermarking.(*Johari A. Bakry, et.al, 2007*) Right back in 2007 used RFID to develop a livestock monitoring system. They employed an RFID tag attached to each livestock to monitor the animal's movement in and out of their steads. (*Vouldimos, Patrizakis, Sideridis and Xylori, 2010*) Also, used RFID to develop a solution which combined RFID and mobile wireless networking to track animals; and use the collected data to monitor key bio characteristics of the animals.(*Sivasankaram at.al, 2013*) Furthermore, wrote that RFID offers superior performance over other AIDCs, because unlike barcoding, it is not an optical technology which depends on line of sight.At this juncture the authors of this paper wish to point out that, generally speaking in the world of connectedness, two groups of objects exist when it comes to connectedness or the ease for the objects or devises to be connected to the world of Internet of Things; namely: *physical-first* and *Digital-first* objects.*Physical-first* objects consist of objects and processes that do not typically generate or communicate digital data unless augmented or manipulated using tagging or RFID. But the ones belonging to the *digital-first* group are such objects or things which are capable of generating binary numbers in form of **0s** and **1s** or rather data; they are capable of communicating data onwards for further use inherently and/or by design.So, in the world of IoT, the *physical-first*objects have to be tagged using digital tools and technologies, such as RFID.In other wods, RFID is a key tool that makes it possible to bring physical objects or devices into the digital realm. The RFID technology relies on microchips that pull data from sensors built into the machines or chips that reside on or in an object or device. RFID can use both "active tags" with a power source …often a battery; and "passive tags" that do not require a battery or other power source.RFID is actually a perfect tool for bridging the connectivity between the physical world and the virtual world. Simply speaking, by attaching a small tag to an object (or by installing a chip into a device) - and setting up an RFID reader, anything and everything can be connected to the Internet. Researchers and system builders now have the ability to tag physical objects and transform anyone, who is carrying a smartphone into a potential data point. This will give rise to tremendous breakthroughs in interconnectedness between devices-processes and, humans. It represents very remarkable and far-reaching implications with positive impacts in all sectors of a given economy. This capability to extract data from a wide array of objects and devices is presently revolutionizing the way system theorists and designers think. Connected devices can now continuously report about their usage, their operating behaviours and mode, their surroundings and conditions, and other information…without the intrusion of human interaction.

1.3 Machine Learning Engine (or AI – Artificial Intelligence)

Artificial intelligence (AI, also referred to as Machine intelligence, MI) is Intelligence displayed by machines, in contrast with the natural intelligence (NI) displayed by humans and other animals. MI entails the study of "intelligent agents": i.e. any device that perceives its environment and takes actions that maximize its chance of success at some goal. Colloquially, the term "artificial intelligence" is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving".Predictions for 2020 promise us many connected devices per person, terabytes of data per second to process, without including IoT-connected dogs and cats. At some point, the internet of things will become the biggest source of data on the planet. And the IoT revolution can let the machines point out where the opportunities truly are. The risks and rewards of machine learning and artificial intelligence (AI) are topics of discussions in nearly every industry circle. Whether it is the promise of cars that not only drive themselves but collectively learn how to drive more safely or the looming threat of apocalyptic war driven by the race for AI supremacy, AI is clearly dominating rhetoric around the heart of man-and-machine interactions.However, no technology evolves in a vacuum, and it is always valuable to evaluate the driving factors leading to widespread change. In the case of AI adoption and deployment, we should remember that other factors are both enabling and driving the change we see today. Like every other technical revolution, the use of AI technology is becoming more prominent because not only is the technology there to support it, but it is clearly an idea whose time has come.The globe is already data rich and information poor. This trend is clearly set to accelerate as the digitalization of industries and life in general proceeds at a breakneck pace. AI offers the promise of handling all that information and extracting insights that humans would never have the time or capacity to see for themselves.

If AI offers the promise of processing immense quantities of data in ways that we can't, then IoT provides the very tangible mechanism for generating that raw data in ways we might not expect. The deep integration of smart devices in our society, our workplaces and our bodies will not only create business and social insight, it will offer the understanding of complex behaviors in ways that quite possibly only AI machines will be able to comprehend. However, it's IoT that could really deliver the data in sufficient volume to both power and drive the promise of AI -- with traffic volumes already climbing into the zettabyte range.Simply speaking, the Internet of things (IoT) is the data flowing between devices. To be able to find needles in this haystack, Artificial Intelligence (AI) is needed. In some years, Artificial intelligence will be an essential part of any IoT system and, will move the IoT revolution to a new level.

1.4 Geo-Positioning Systems (GPS); GPS &IoT (Geo IoT): A Perfect Match

The Global Positioning System (GPS), is a space-based radio navigation system and or a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellitesAs one of the first methods to track and catalogue digital data of the physical world, GPS has had an essential influence on Internet of Things technologies. IoT can collect and quantify large amounts of data for everything from personal health to vehicles; GPS tracking is needed to provide location information for these objects. For example, IoT could sense when a driver ends up in a crash or stranded due to vehicle malfunction, but GPS tracking provides the location information that emergency vehicles will need to respond in time. A house pet may run out the front door without its owner noticing, a GPS-capable tag may detect if the animal is in distress. GPS and IoT complement each other to form a more complete, usable set of interconnected data.Furthermore, IoT monitors objects and hardware to give real-time information and data about the device’s operations, while GPS provides the physical coordinates of the hardware or object. With these systems working in tandem, they form the foundation of Smart Agriculture, smarter cities, innovative products such as self-driving cars and health-related wearable technologies, and a vast, interconnected ecosystem that allows for smart devices to interact with sophisticated locating capabilities to achieve goals previously thought impossible.

1.5 Robotics& Cloud Robotics

Robotics technologies are used to develop machines that can substitute for humans. Robots can be used in any situation and for any purpose. Today many are used in dangerous environments (including bomb detection and de-activation), manufacturing processes, or where humans cannot survive. Robots can take on any form but some are made to resemble humans in appearance. This is said to help in the acceptance of a robot in certain replicative behaviors usually performed by people. Such robots attempt to replicate walking, lifting, speech, cognition, and basically anything a human can do. Many of today's robots are inspired by nature, contributing to the field of bio-inspired roboticsCloud Robotics may be seen as emerging field of robotics that is rooted in the cloud computing, cloud storage, and other existing Internet technologies, centered around the earned benefits of the converged cloud infrastructure and shared services that allows robots to take benefit from the powerful computational, storage, and communications resources of modern data centers attached with the clouds, while removing overheads for tasks such as, maintenance and updates, and enhancing independence on the custom middleware platforms, entailing additional power requirements which may reduce the operating duration and constrain robot mobility and increase operation costs by covering cloud data transfer rates to offload tasks without hard real time requirements..

Internet of robotic things (IoRT)

In summary, Internet of Robotic Things is envisaged to be positioned on top of the Cloud Robotics paradigm, while leveraging certain aspects of Cloud computing such as virtualization technology, and three service models (i.e., software, platform and infrastructure), while utilizing IoT and its enabling technologies to empower tremendous flexibility in designing and implementing of new applications for networked robotics to achieve the goal of provisioning distributed computing resources as a core utility. It shares certain aspects with Cloud Robotics and Internet of Things but differs from them in other aspects. Therefore, it offers unique benefits and imposes distinctive challenges to meet its requirements.

Recent Works &Solutions of Smart Systems with IoT

(Scroxton, Alex, 2015) reported that a company,Eltopia working in collaboration with the University of Minnesota, USA succeeded to build an IoT based solution which is helping solve the problem of CCD(Colony Collapse Disorder) plaguing honey bees and their colonies.
(*Anjum, Zafar, 2016*) wrote how IoT using smart sensors technologies is helping to reduce acute congestion in Singapore highways; he also reports the use of IoT enabled innovations in the management of health of the elderly.(*Ranzani, Amanda 2016*) reported the successful use of IoT enabled smart sensors to monitor in real-

time, variations in climate change as it affects a very valuable national park in Peru. In this solution, cameras and sensors were used to enable the collection and monitoring of biosphere data; the collected data was analysed and used to track humidity, temperatures, solar radiation, atmospheric pressure and the concentrations polluting gases such as CO2, NO2, CO and CH4. The researcher reports that the available results are presently helping to find solutions on ways to further preserve and protect the valuable rain forest parks in Peru, in an effective manner.(*Puri, Deepak, 2016*) wroteand reported about the successful use of IoT in combination with “recycled old cellphones” to protect the rainforest from excesses logging. In this solution the individuals who felled and logged the trees indiscriminately were successfully tracked. Local authorities were quickly alerted by in-built trigger alerts within the integrated system.o buttress the point that IoT is no more a buzz word, even in Nigeria, (*Amina Doma 2016*), a Baze University Abuja, graduate used C# to build an Android application for Sahad Stores, Abuja. Her solution explored some of the huge retail store management opportunities with IoT. She used RFID beacons and smart chip solution to track store inventory from the warehousing to customer delivery. Customers are able to use their smart phones or a wearable device to quickly scan QR codes and call up product information, virtual product images.*ThisDay News- Nigeria of 04/12/2017* alludes to the current concerted efforts geared towards incorporating cattle tracking to guard against cattle rustling in the State of Katsina. The editors write that “The Katsina state government is to engage a private firm that will introduce cattle tracking technology to guard against cattle rustling in the state. At a meeting with Governor Aminu Bello Masari at the Government House in Katsina, the Chief Executive of the company, Mr. Emilio Sapina, said the company is ready to partner the state government in its efforts to provide security for pastoralists”.

The initiators of this effort believe that once a tracking chip is installed below the skin of a cow, the animal could be tracked whenever it is stolen or goes missing, and that the technology minimizes loses for livestock farmers and will prove valuable in states that suffer the menace of cattle rustling and the accompanying social strife.

1.2 Conclusion & the Case for Smart Agriculture in Nigeria

Just like other parts of the World,Nigeria’s ICT penetration and usage have improved exponentially in the last decades. Thus presently, Nigeria has the capacity to leverage and implement Smart Agriculture as a solution for its commercial and local farming. In a world where the Internet of things is quickly accelerating the adoption and use of smart devices in farming, the Nigeria’s agricultural sector can surely benefit. The benefits of such adoption would be realised in the forms of improved water conservation by the sub-arid production zones of the country, improved livestock farming and management, improved land melioration and land-use, reduced environmental stress on limited biomass, improved soil management, soil mapping and erosion control, and lowered operation costs. Furthermore, planners would be able to accurately track production rates by zones over time to allow for detailed prediction of future agricultural yields and value of farming expanses across the country.It should be noted that Agriculture is among the sectors most vulnerable to the impacts of climate change in Nigeria; this is exemplified by the continuous “drying up and receding” of the basins (like the Lake Chad basin) located by the northern strips of Nigeria. Consequently, there exists a persisting pressure on the limited agro-hydro-ecological potential of these areas. Such land-use pressures resulted and are still resulting to conflicts. The authors strongly believe that the solution ultimately will come from the adoption of Smart agriculture and land-use.Likewise many environmentalists in Nigeria believe that an effective tracking of Nomadic cattle-grazing and movements enabled by smart tracking devices would greatly minimize the number community clashes between nomadic herdsmen and the settled rural sedentary farming communities. This would go a long way to help settle the persisting strife and communal disputes, tensions, which most often degenerate into communalwars between the peoples.

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