Singularity is the Future of ICT Research

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Abstract

Research in Information and communications technology (ICT) is tilting towards the Singularity. Technological singularity refers to the hypothetical future emergence of greater-than-human intelligence through technological means, resulting in explosive super-intelligence. Since the capabilities of such intelligence would be difficult for an unaided human mind to comprehend, the occurrence of a technological singularity is seen as an intellectual ***event horizon****, beyond which events can not be predicted or understood. Proponents of the singularity call the event an "****intelligence explosion****" which is a key factor of the Singularity where super-intelligence design successive generations of increasingly powerful minds. The originator of the term – Vernor Vinge - and popularized by Ray Kurzwei has proposed that Artificial Intelligence, human biological enhancement or brain-computer interfaces could be possible pushers of the singularity conundrum. It is envisaged that if the singularity does occur, the predicted super-intelligent machines might take over full control of human activity resulting in the possibility of humans becoming subservient to machines. It could also lead to existential risks of the human race. The authors propose a paradigm shift in the current education practice in ICT towards advanced practical and dynamic training in Artificial Intelligence, Robotics, mechatronics, nanotechnology, Software Engineering and now the Internet of all Things!. Government would need to develop positive political will to invest in Research and Development and create an enabling environment for supporting innovation if the black race are not to be left one hundred years behind Western nations..*

1.0 Introduction

What is technological singularity? A technological singularity is a hypothetical event occurring when ***Technological progress*** becomes so rapid and the growth of ***artificial intelligence*** is so great that the future after the singularity becomes qualitatively different and harder to predict. The Singularity is an era in which our intelligence will become increasingly non-biological and trillions of times more powerful than it is today—the dawning of a new civilization that will enable us to transcend our biological limitations and amplify our creativity [1]

Artificial Intelligence (AI) is the area of computer science focusing on creating machines that can engage on behaviors that humans consider intelligent. The ability to create intelligent machines has intrigued humans since ancient times and today with the advent of the computer and 50 years of research into AI programming techniques, the dream of smart machines is becoming a reality. Researchers are creating systems which can mimic human thought, understand speech, beat the best human chess player, and countless other feats never before possible. Find out how the military is applying AI logic to its hi-tech systems, and how in the near future Artificial Intelligence may impact our lives, AI, Robotics, nanotechnology, mechatronics are collaborative agents of technological singularity. The singularity is already here! Think of modern houses now remotely controlled from far distances, think of e-commerce and electronic banking where you can be up-to-date with all your business and banking transactions on minute basis. However the real singularity is referring to an envisaged future where intelligent machines built with the tools of AI, nanotechnology, robotics, mechatronics will completely change the future of humanity such that machine will be the controller of global activities with less assistance from the machine creators to the extent of challenging the existence of its creators![2]

There is a total of 16 major fields in science and technology where current research is taking place around the worlds' best learning and research centres. Of these major fields, AI, Robotics, nanotechnology, Electronics and Energy are the busiest and converging towards Internet of all Things. All the new research directions points to the coming of technological singularity. You may also have observed that six main technologies are converging towards the singularity – AI, Nanotechnology, Electronics, Robotics, Information Technology and communications.

Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. It relates to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control. The key objectives of our mechatronics program is to provide rapid advancement in practical developments in the field of mechatronics ranging from application areas including consumer product design, instrumentation, manufacturing methods, computer integration and process and device control, and will attract a interest from across the industrial and academic research spectrum. Particular importance will be attached to aspects of innovation in mechatronics design philosophy which illustrate the benefits obtainable by an a priori integration of functionality with embedded microprocessor control. A major item will be the design of machines, devices and systems possessing a degree of computer based intelligence [3]

Wikipedia has defined *Nanotechnology* as "the study of manipulating matter on an atomic and molecular scale." Generally, nanotechnology deals with structures sized between 1 to 100 nanometre in at least one dimension, and involves developing materials or devices possessing at least one dimension within that size. Quantum mechanical effects are very important at this scale, which is in the quantum realm.[3]

Global Current Research Directions

Of the six science and technology strongholds identified above all are converging towards the singularity, leading to unique research trusts, thus:

- I.T. and Communications
- Artificial Brain for applications in neurological treatment
- Virtual Reality for entertainment and education
- AI for creating intelligent devices
- 4G cellular communication for pervasive computing, machine translation for cross-cultural communication
- machine vision for biometrics and control of processes
- Speech recognition
- Cybermethodology
- Machine augmented cognition and exotics
- Mobile collaboration to extend the capabilities of video conferencing for use on hand-held devices.
- Semantic Web for making the web machine-readable
- Fourth-Generation Optical Disks and Holographic data storage for storing and archiving data previously erased for economic reasons
- Optical computing for smaller, faster, lower power consuming computing.
- Quantium computing for faster computing, particularly in chemical modeling.
- Quantum Cryptography for securie communications.
- Radio Frequency Identification for smart storage
- Three Dimensional Integrated Circuits
- 3D printing for rapid processing of plastic objects

Robotics

Self-reconfiguring modular robots to change the way we make physical structures and
machines. Swarm Robotics to make for autonomous and space construction Modular nanotechnology or nano-robotics for designing and building smart machines Powered exoskeleton for heavy lifting, paralysis, muscle related diseases, warfare and construction as well as ***molecular robotics***, i.e., robotic devices that are molecular both in their size and precision

(b) **Electronics**

Spintronics for data storage
Memrisistor for use in analogue electronic and Artificial Intelligence
Thermal Copper pillar bump for electric circuit cooling

Micro-fluidic actuators

Small device thermoelectric power generation Flexible Electronics for developing flexible and folding electronic

devices such as smartphone, flexible solar cells which are lightweight
Electronic nose for detecting spoiled food, chemical weapons and cancer

Research Directions in Artificial Intelligence -

Nano-Technology or Nano-scale Engineering

Wikipedia has defined nano-technology as the study of manipulating matter on an atomic and ***molecular*** scale. It can also be defined as the engineering of functional systems at the molecular scale. The term was popularized by **K. Eric Drexler** in the 1980s. Generally, nanotechnology deals with developing materials, devices, or other structures possessing at least one dimension sized from 1 to 100 nanometers. Thus, Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, nanotechnology refers to the projected ability to construct items from the bottom up, using techniques and tools being developed today to make complete, high performance products. One nanometer (nm) is one billionth, or 10–9, of a meter. Nanotechnology will help man achieve the ultimate in precision: almost every atom in exactly the right place; make complex and molecularly intricate structures as easily and inexpensively as simple materials. Molecular nanotechnology will let us build new and entirely novel molecular machines and reduce manufacturing costs to little more than the cost of the required raw materials and energy.

Nanotechnology is a key converging factor (driver) towards the singularity. Current evolution and research trust in nanotechnology include:

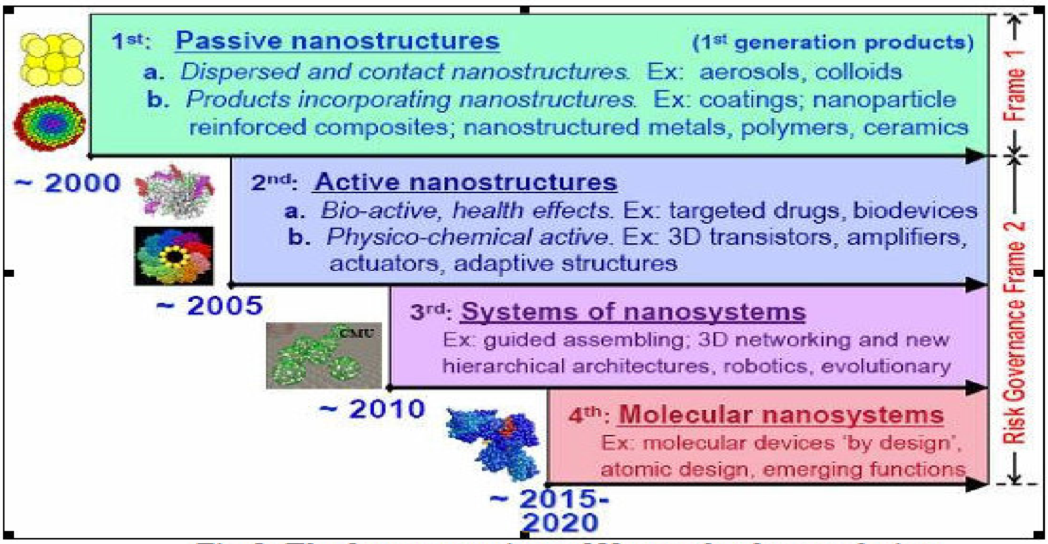

Fig. 1: The four generations of Nanotechnology evolutions (source: http://www.crnano.org/whatis.htm)

Molecular robotics e.g., robotic devices that are molecular both in their size and precision

- Nanotechnology Devices and Sensors . These include
- Resonant Tunneling Diode (RTD)
- Single Electron Transistor (SET)
- Quantum Dot (QD)
- Quantum Effect Devices
- Building quantum wells using molecules
- Electromechanical Devices
- Using mechanical switching of atoms or molecules
  - Electrochemical Devices
  - Chemical interactions to change shape or orientation
  - Photoactive Devices
  - Light frequency changes shape and orientation.

Sensors may include sensing agents capable of detecting weapons agents or drugs- Nanotechnology may make possible small, accurate, and easy-to-use sensors to detect a variety of substances, including chemical, biological, radiological, and explosive agents, as well as drugs.

Electron Microscopy - Any of a class of microscopes that use electrons rather than visible light to produce magnified images, especially of objects having dimensions smaller than the wavelengths of visible light, with linear magnification approaching or exceeding a million (106).

Engineering Materials for Energy - These include:

Thermal conductivity -The thermal conductivity is the rate of heat transfer through a material in steady state. It is not easily measured, especially for materials with low conductivity but reliable data is readily available for most common materials.

Thermal diffusivityb - The thermal diffusivity is a measure of the transient heat flow t
hrough a material.

Specific heat - The specific heat is a measure of the amount of energy required to change the temperature of a given mass of material. Specific heat is measured by calorimetry techniques and is usually reported both as CV, the specific heat measured at constant pressure, or CP, the specific heat measured at constant pressure.

Melting point -The melting point is the temperature at which a material goes from the solid to the liquid state at one atmosphere. The melting temperature is not usually a design criteria but it offers important clues to other material properties.

Glass transition temp - The glass transition temperature, or Tg is an important property of polymers. The glass transition temperature is a temperature range which marks a change in mechanical behavior. Above the glass transition temperature a polymer will behave like a ductile solid or highly viscous liquid. Below Tg the material will behave as a brittle solid. Depending on the desired properties materials may be used both above and below their glass transition temperature.

Thermal expansion coefficient - The thermal expansion coefficient is the amount a material will change in dimension with a change in temperature. It is the amount of strain due to thermal expansion per degree Kelvin expressed in units of K-1. For isotropic materials " is the same in all directions, anisotropic materials have separate "s reported for each direction which is different.

Thermal shock resistance - Thermal shock resistance is a measure of how large a change in temperature a material can withstand without damage. Thermal shock resistance is very important to most high temperature designs. Measurements of thermal shock resistance are highly subjective because if is extremely process dependent. Thermal shock resistance is a complicated function of heat transfer, geometry and material properties. The temperature range and the shape of the part play a key role in the material's ability to withstand thermal shock. Tests must be carefully designed to mimic anticipated service conditions to accurately asses the thermal shock resistance of a material.

Creep resistance - Creep is slow, temperature aided, time dependent deformation. Creep is typically a factor in materials above one third of their absolute melting temperature or two thirds of their glass transition temperature. Creep resistance is an important material property in high temperature design, but it is difficult to quantify with a single value. Creep response is a function of many material and external variables, including stress and temperature. Often other environmental factors such as oxidation or corrosion play a role in the fracture process.

Ethical, Environmental, Economic, Legal and Social Issues in Nanotechnology - raising awareness of the benefits, the dangers, and the possibilities for responsible use of advanced nanotechnology; expedite a thorough examination of the environmental, humanitarian, economic, military, political, social, medical, and ethical implications of molecular manufacturing; and to assist in the creation and implementation of wise, comprehensive, and balanced plans for responsible worldwide use of this transformative technology.

Materials & Interfacial Chemistry - This involves research in physical chemistry which occurs uniquely at interfaces found in natural systems and those engineered or grown to provide environments with specific properties. Rresearch in this field spans traditional boundaries drawing together experts in surface science, heterogeneous catalysis, electrochemistry and biophysics supported by first principles Modelling. Typical systems currently investigated are bimolecular building blocks (especially amino acids) adsorbed at surfaces and interfaces; enantioselective heterogeneous catalysis at gas-surface and liquid-surface interfaces; growth and properties of ultra-thin films; transition metal oxide surface chemistry; the interaction of water with solid surfaces; templating of nano-materials growth by exploitation of novel self assembled 2D and 3D phases; and the structure and self-assembly of proteins (e.g. fibrillar structures)

Materials for Energy and the Environment - exploration of materials that can help produce cleaner and more efficient sources of energy. Clean energy conversion, hydrogen generation and storage, fuel cells, green manufacturing and biofuels/metabolics are l subjects of active research in this field.

Materials for Molecular Diagnostics - Diagnostics are valued based

on how well the information provided improves clinical decisions. Traditional diagnostics include known biology or associations of single analytes (glucose, cholesterol, etc.), Cheapest, most efficient and convenient technology wins,

Molecular diagnostics include complicated biology of critical clinical

decisions can be addressed. Examples of Molecular Diagnosis include: Myriad Genetics: BRACAnalysis® which has the capacity to Assess inherited risk for breast cancer, Mutations in BRCA1 and BRCA2 by DNA sequencing , Genomic Health: Oncotype DX® and predict benefit of chemotherapy and risk of recurrence in breast cancer patients, Gene expression levels of 21 genes from tumor tissue, Genentech: HER2/neu, prediction of response to to Herceptin in breast cancer patients

Metrology for Nanotechnology - Metrology is the science of

Measurements, and nanometrology is that part of metrology that relates to measurements at the nano-scale.

Molecular Scale Devices - The research addresses devices to represent, store, process and exchange information at the atomic and molecular scale, as a basis for fully functional ICT devices and systems. These devices and systems should rely on new scalable concepts and architectures enabled by atomic precision and control, exploit intrinsic properties of atoms and molecules, realize their interconnection, interface them to the mesoscopic world and ultimately have an impact on future information processing systems.

Nano Life Sciences - investigation into the fields of synthetic

biology, computational biology, protein structure, intermolecular membrane dynamics and microfluidics devices for biological analysis.

Nanotechnology Research - Broad spectrum research in the science, design and application of nanotechnology.

Proton Exchange Membrane Fuel Cells - Wikipedia defines a fuel

cell as a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Hydrogen is the most common fuel, but hydrocarbons such as natural gas and alcohols like methanol are sometimes used. Fuel cells are different from batteries in that they require a constant source of fuel and oxygen to run, but they can produce electricity continually for as long as these inputs are supplied.

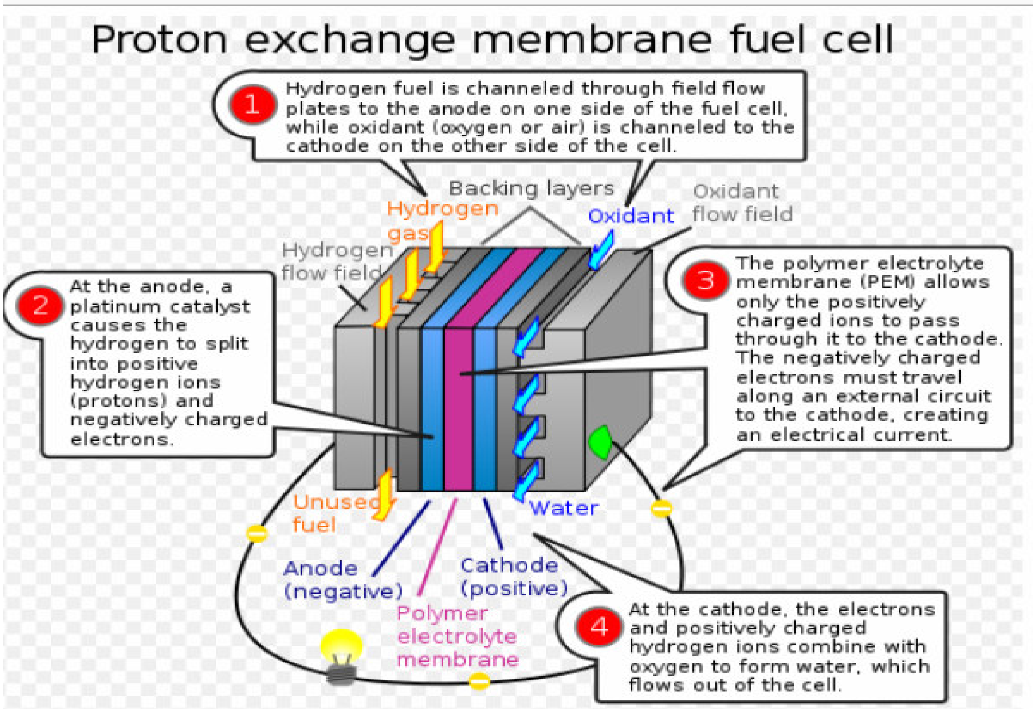

Fig.2 Construction of a high temperature PEMFC: Bipolar plate as electrode with in-milled gas channel structure, fabricated from conductive composites (enhanced with graphite, carbon black, carbon fiber, and/or carbon nanotubes for more conductivity);[11] Porous carbon papers; reactive layer, usually on the polymer membrane applied; polymer membrane, (source: wikipedia)

Solid Oxide Fuel Cells

Supramolecular Nanoscale Assembly
Nanotechnology Theory and Modeling
All these innovations are leading to obsolescence of existing technologies and the emergence of new ones demanding additional education and research. These include;
CMOS technology is approaching saturation – problems in the nanometer range. Several new possibilities are emerging such as:
Carbon nanotubes (CNT)
Single-electron transistor (SET) and quantum dots (QD)

Research and Development (R&D) in Africa

African governments are paying lip-service to R& D because less than 10% of national budgets are devoted to R&D in national annual budgets of many African countries. Consequently, R&D centres are poorly equipped. These centres are also ill-equipped with qualified and experienced research, thus leading to barren results. lThis is part of what has dragged Africa back in science and technology progress.

The present - Poorly equipped Laboratories in African tertiary institutions Most teaching laboratories in African tertiary institutions are very ill-equipped. The budgetary allocation to education sector ensures that physical laboratories for teaching and learning science and technology are laughing stock. Where there are experienced teachers, the teachers lack the enabling environment to transfer practical skills leading also to the production of half-baked graduates. This also radiates look productive output because of poor training and inadequate skills transfer. Employers have cried out that the quality of graduates produced by tertiary institution in Africa is unemployable! The paucity of good training laboratories are even worse in the case of Information Technology Training. Most institutions offering Engineering have no foundries, nor good Robotics labs. I do not know how the miracle of transforming knowledge people to productive workforce without good training labs and quality curriculum.

5.0 The future

For Nigeria and the black race to remain relevant in our emerging information society and new world economic order galvanized by information technology, there is urgent need for paradigm shift in our school curriculum and knowledge transfer mechanisms. First we need to retool the curricular of our educational institutions from primary to tertiary to reflect the needs of an emerging world industry and commerce driven by Information Technology. Tertiary institutions in African should pay more attention to disciplines such as Artificial intelligence, mechatronics, robotics, nanotechnology, Software Engineering and biotechnology. Government need to develop positive political will to train new crop of dedicated academics to face these new challenges of knowledge transfer to serve the emerging knowledge economy. This can only be realized however through adequate budgetary provision and monitoring mechanism to ensure that budgets allocated for enhancing educational development and R&D are really deployed for reasons for which they are provided. Our schools need to change from chalkboard to electronic boards that can be used for video conferencing, virtual reality laboratories, e-learning to complement face-to-face interactions in the class room. Unfortunately, there is serious resistance by government to give full recognition and encouragement to e-learning as a means of educational diffusion and knowledge transfer. While in the West e-learning is fused with traditional learning, the technology is hampered by absence of good power supply and resistance to change. These obstacles would need be addressed by government and Public Private Partnerships. No serious government can afford to treat the forthcoming singularity with a kid-globe. This was amply captured by the sayings of the former Unesco scribe – M'bow some two decades ago:

"*Information Technology has opened up such tremendous vista for modern societies that any failure to master it would mean a life of permanent sub-ordination. For information technology is more than a form of power, it is a power* *system. The technology which it involves is not just one form of technology among others but an ability to make use of other techniques to give or refuse access to a whole range of scientific data and knowledge and thus to design new models of development".[19]*

This journal article is mind provoking. Every African citizen in leadership position needs to read and digest this article. It is a true reflection of the future and the new world economic order.

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Note on Ref.11;

Ray Kurzweil, The Singularity is Near, pp. 135-136. Penguin Group, 2005. The context for this statement is as follows: "we will be producing about 1026 to 1029 cps of nonbiological computation per year in the early 2030s. This is roughly equal to our estimate for the capacity of all living biological human intelligence ... This state of computation in the early 2030s will not represent the Singularity, however, because it does not yet correspond to a profound expansion of our intelligence. By the mid-2040s, however, that one thousand dollars' worth of computation will be equal to 1026 cps, so the intelligence created per year (at a total cost of about $1012) will be about one billion times more powerful than all human intelligence today. That will indeed represent a profound change, and it is for that reason that I set the date for the Singularity—representing a profound and disruptive transformation in human capability—as 2045."