INFORMATION RE-ENGINEERING METHODOLOGIES FOR ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

For several decades, technology engagement in various sectors of the economy has been on the increase and information engineering (IE) is centered on development of information systems (IS). Re-engineering incorporate new computational approach to generate, distribute, process and use information. IS as decision support tools are computer-based infrastructures, which collect, process, store/manage and act on information. Information resource, a critical ingredient for socio-economic development required re-engineering methodologies to combat the menace of humanitarian crises. Though, TVET objectives of sustainable development centered on poverty reduction, production improvement, safety and good health, imminent challenges of hazards, local disasters, life-threatening conflicts had increased peoples' vulnerability to humanitarian crises. This paper adopts Trajectory Range Query (TRQ) and *k Nearest Neighbour* (TkNN) algorithms (SpatialHadoop) for *analysis* and *inferencing* and the computation implemented shortest routes to query safety points in shortest intervals. Capacity building in ICT technologies via TVET strategy help unlocks greater potentials for greater services when objectively collaborated with STEM agenda. Engaging more women in information re-engineering reduces gender-imbalance problems. Increased women participation in IRE fosters more wisdom-driven analysis/inferencing, which significantly effect rapid talent-growth and skill- boost projections of TVET. Spatial operation and query analysis algorithms are useful for transportation and advance pattern-mining computations. They decisively provide solutions in crises' handling. More women in STEM-related disciplines as information re-engineering is a focus to revamp TVET objectives and achievable goal of gender-balance is also an indicator of socio-economic growth and development.
KEYWORD: deep-learning, hadoop, kNN, trajectory, TVET

1 INTRODUCTION

Information re-engineering (IRE) computational paradigm consists of data-oriented analysis and process-oriented techniques for design, development and maintenance of information systems (IS) to support strategic decision-making processes and missions of any nation. Information engineering (IE) is specifically concerned with the application of science and technology in the development of qualitative information systems, offered as computer-based solutions and implemented as decision support systems (DSS) and tools engaged in the management of humanitarian crises globally. Objectives of IE include an ability to design, develop and maintain IS to support strategic decision processes.

IE methodologies encapsulate information acquisition, processing, inferencing, analysis and storage as corroborated in Sadiku, Shadare and Musa, (2017) but Information technology is characterized with efficient knowledge-driven computations, well-articulated with programming, analysis, management etc. techniques and skills that incorporate content-centric and wisdom-driven engagements (Bonnaud *et al*, 2010). Building on existing IT infrastructure, information re-engineering is considered to apply in the formulation of IT-based security-related solutions, which will add value to nation's socio-economic growth and development.

Generally, SDGs centered globally on improving socio-economic status of the society through various means of poverty reduction (through various inclusions of health, finance, education etc. to address imminent disasters); hunger suppression (through improved production strategies of many agricultural products, drought monitoring and online pricing regulations via economic-dependent consumer price indexes); good health and well-being attainment (through literacy penetration and various unemployment reduction strategies) among others. Nations' GDP grows with poverty reduction, improved production, human (service) mobility, industries, affordable energy, decent work provision, clean water supplies and quality education among others (Ojokoh, 2019).
Humanitarian crises are great sabotage to economic growth, more so as the general aftermath effects hinders developments in all ramifications. Societies continuously battered with various forms of crises are characterized with

retrogressing economy and poor gross domestic product (GDP) as witnessed in most developing nations. GDP monetarily measures the market value of finished goods (materials or products) and services (skilled or trained) produced annually. Downward GDP steadily characterize crises periods if not properly controlled. Engaging information engineering technologies (such as cloud computing, machine learning, deep learning etc.) to create specialized IT applications in decision support services to mitigate various crises becomes a necessity.

Specifically, larger percentage of Nigerians are most vulnerable. Her hardest-to reach people are impacted by various crises including the challenges of poverty, well-being hazards, health disasters and other life-threatening conflicts. Peoples' vulnerability to humanitarian crisis (such as insurgency, Boko Haram, Fulani herdsmen attacks, pipeline vandalization, terrorist attacks, kidnapping, ritual killings, robbery, ignorance, illiteracy penetration among others) are visibly imminent. To address these and many other problems, some approach to increase resilience is conceived and this paper adopts information re-engineering technologies to complement IT-approaches to mitigate humanitarian crises and other DSS-based missions.

Also, Technical and Vocational Education and Training (TVET) in Nigeria is faced by many challenges, including gender inequality and inadequate capacity. Majority of students who enroll in TVET programmes are males, with less than 40% being female. Also, TVET institutions fail to teach skills and knowledge fit for the present and future labour markets because of inadequate ICT infrastructures (tools, skill/capacity etc) to deliver (TVETA, 2018). It is on these premises that the idea of improving IT capacity is conceived in this paper, as a strategy to deliver and impact socio-economic development.

2 RELATED WORKS

Technical and vocational education is a continental strategy to address the challenges of education and technical and vocational training to support economic development, create wealth and reduce poverty. Discussions related to this study includes TVET, STEM and IE model.

2.1 Technical and Vocational Education and Training (TVET) strategy

TVET is a form of education for those who need it, those who want it, and those who want to progress by it. As a result-oriented form of education, Okoye and Chijioke (2013) advocates that it is the development of the head (*knowledge*), training of the hand (dexterity) and enrichment of the heart (*conscientiousness and painstaking*). TVET is also a total deviation from previous emphasis of 3Rs (reading, writing and arithmetic) to 3Hs (head, hand and heart). In line with this vision, TVET strategies of aggressive capacity building is workable with technology adaptations to transform national production, industrialize the economy and keep abreast of developing and emerging technologies to impact society the more.

Though, TVET continental strategy is an action guide qualification and certification on skill, intelligence, knowledge, experience, competence, talent and special abilities (TVET, 2019), TVET's offer of formal, non-formal and informal learning for social equity, inclusion and sustainable development incorporates creativity. These objectives contribute immensely to technological development required to formulate solutions needed in addressing humanitarian crises. Such capacity development and portability of TVET qualifications within national borders is a conviction of IT-solution for economic development.

2.2 TVET Challenges

Reported in UNESCO (2018), TVET in Nigeria is characterized with many challenges including:

(i) Gender inequality, which has been a long-term problem. Female enrolment in TVET programmes are considerably poor in STEM-related disciplines;
(ii) Inadequate infrastructure constraint. Inadequate and obsolete infrastructures (lecture rooms models, delivery styles, laboratories and workshops);
(iii) Financing, relating to insufficient budgetary allocation, which make most TVET institutions to be unsustainable;
(iv) Poor capacity development and inadequate provision for teacher training. Corresponding qualifications, knowledge and skill are grossly absent to fit into the present and future labour markets; and
(v) Inadequate ICT facilities to integrate e-learning, which makes it hard to improve the quality of teaching and learning outcomes.

2.3 Science, Technology, Engineering and Management (STEM)

STEM objectively integrates four disciplines (science, technology, engineering and mathematics) into a cohesive learning paradigm based on real-world applications (Okafor, 2012). STEM campaign addressed the inadequate number of teachers skilled to educate students and learners in the subjects (Hom, 2014). A skilled workforce is basically required for driving industrial and socio-economic growth of nations and TVET holds the key to building technical and entrepreneurial workforce. TVET as one major priority of Government's development agenda, established under TVET Act, regulates and coordinates training, accredits programmes, institutions and trainers (TVETA, 2018).

2.3 Features of information engineering (IE)

IRE integrate tools, techniques and methodologies to develop IS solutions applicable for handling humanitarian crises. IE system model presented in Sadiku *et al*. (2017) is characterized with common data (mobile phone records) which is consistent in meaning and structured. Such information are applicable for IRE as are characterized with operational components required for decision support services. Major characteristics among others includes:

(i) information sharing, facilitated through common data infrastructure, useful for operational and decision-support purposes, which are central to any IS;
(ii) multi-dimensional systems that uses various hardware and communication facilities to provide operational support for re-engineering;
(iii) connectivity techniques with capability to communicate with people and other machines (computers);
(iv) artificial intelligent support that enables complex rule-base systems, machine learning and deep-learning approaches capture expert knowledge; and
(v) computer aided software engineering (CASE) tools, selected to automate IS development steps.

Information engineering model adopted from Sadiku *et al*. (2017) is modified and presented in fig.1 to show the various concepts and their relationships. Handling humanitarian crisis is a major determinant for economy growth and development because societal well-being is anchored on safety and security of lives and properties in the real world.

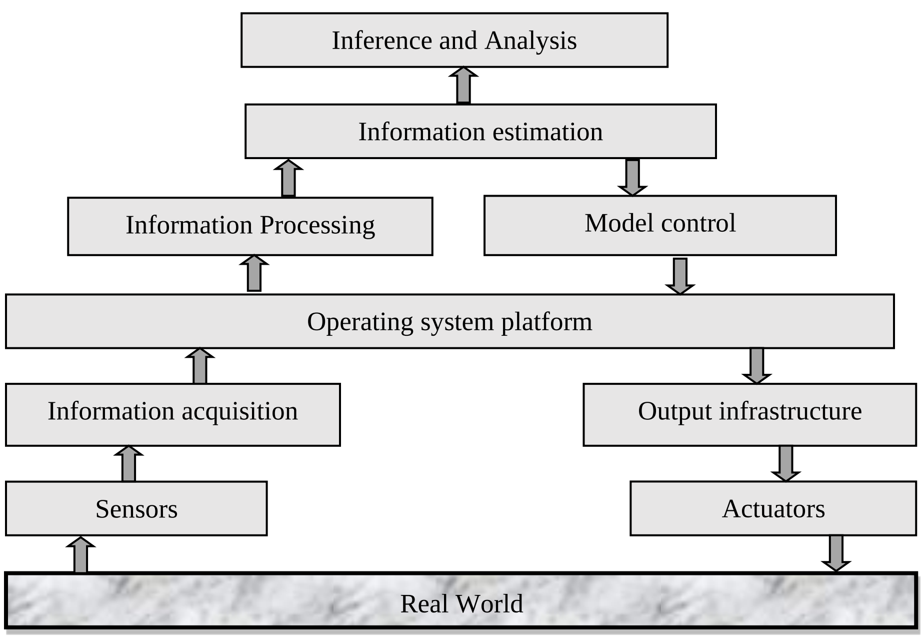

Fig. 1 Conceptual information re-engineering model
(adopted and modified from Sadiku *et al.,* 2017)

3 METHODOLOGY

Adopting the heterogeneous multiple platform defined and developed in Jiamin and Ralf (2012); Sijie *et al.*(2018)

deployed the MapReduce analysis to implement trajectory operations built on-top of Hadoop platform as similarly implemented in Uber (2019). Given query predicate on query point *P(x,y)* and time interval $[t_1, t_2]$, the three-dimensional query predicate finds all trajectories overlapping with defined query region (using R*angeQuery*) within specified space and time.

With language, *finding all routes entering RUGIPO campus between January and June 2018* implemented as object, trajectories captured ordered sets of intermediate states was assumed for moving pedestrian (student/staff) as dynamical systems. Temporal slicing mechanism was used to break the trajectories into sub-sequences. With general view to capture pedestrians including *passengers* waiting endlessly on the highways, wandering *Fulani Herdsmen*, *commuters, loiters* etc., some routes were deliberately avoided as spaces or co-ordinates not connected. Tracks, lanes, paths are lines and points marked as a result of time and evolution of crisis defined. Information acquisition by sensors was effected on various routes as applicable in real world.

On the generic (open source Hadoop) distributed processing framework, *Trajectory Range Query (TRQ)* algorithm was implemented in three steps to achieve *temporal filtering*, *spatial searching* and *spatio-temporal refinement*. Cleaning the dataset of similar trajectories, obtained from defined ranges were carried out to remove duplicates. Libraries provided within framework implemented the analysis for duplicates' removal. Trajectories were replicated between partitions as the queries run several times. This is re-engineering approach.

Then, inferencing was implemented on Hadoop layer components – *indexing* spatial-based file data; *operations* of RangeQuery, ST-Join, kNN, similarity; and *language* of time-interval, *MapReduce* tasks were implemented. Spatio-temporal information was analyzed as set of spatio-temporal *points*, path as *lines* and spaces as *co-ordinates* not connected (Hadoop, 2019).
Fig. 2 shows the code snippet of TRQ for loading and querying trajectories to compute similarity between the data records in ST-Hadoop.

Objects	=	**LOAD** 'point' **AS** (id:int, **STPoint**);
Intermediate	=	**FILTER** Objects **BY**
		Ovelaps ((**Rectangle** (x_1, y_1, x_2, y_2)),
		Interval (t_1, t_2);
		GROUP Object **BY** (id)
		FOREACH $Object(id) **Search** Trajectory(id)
Result	=	**SIMILAR** Object threshold:*T* **From** Intermediate

TRQ query finds similar objects within defined rectangular area represented by two corner points (x_1,y_1; x_2,y_2) at defined time intervals. The objects were loaded as trajectories spatio-temporal points and ST-Hadoop finds all records overlapping with the defined time interval. Retrieved records were grouped and trajectory_ID of entire trajectory sequence retrieved from secondary inverted index. Similarity between data records was evaluated and finding nearest point to query point during defined time interval was accurately computed.
Distributed spatial systems are extensions of MapReduce platform, dedicated for spatial analysis. Other versions including SpatialHadoop, ScalaGiST, Hadoop GIS and Summit are applicable for analyzing trajectory data.

3.1 AI Deep Learning Methodologies

Computational approach of AI deep learning was used on a local (campus) map section as input with focus on pedestrians as dynamical objects of trajectories in time of crises. Objects captured by sensors were viewed as array of pixels enable randomization, and numerical numbers between 0 and infinitely large integers were assigned. Approach used in the methodologies include initialization (randomization or Gaussian distribution) at input layer, sampling (pooling) and Batch normalization (as batch models) created at hidden (operation) layers and output regularization called dropouts measured at output (language) layer in resonance with methodology defined in Data Turks (2018). Uber (2019) implemented Hadoop as backbone for storing data as non-indexed heap files, so adopting the ST-Hadoop framework defined in Louai *et al.* (2018) enable computed inferences to be feasible and validated for use as DSS for formulated technologies.

4 RESULTS AND DISCUSSION

Re-engineering techniques, analysis and inferencing computational technique defined in ST-Hadoop IRE model is suitable for accurate prediction performance and MapReduce tasks for many applications relating to intelligent transportation system and advance pattern mining queries. Similarity query algorithm shown in fig. 2 would help predict movement of pedestrian (student/staff) in time of crises. The result output (actuators) are efficient DSS tools, jointly used with other computational technologies (formulated ICT-solutions) is very suitable in the handling of humanitarian crises. Predictions obtained from massive data management techniques evolve to support sophisticated technical infrastructures based on skill and capacities. Formulated technologies (ICT-solutions) applicable in humanitarian crises includes:

- connectivity through BGAN: Broadband Global Area Network (BGAN) devices can offer satellite connectivity in remote humanitarian crisis zone. It enables topology options using portable terminals, easily connectible to laptops for broadband Internet;
- distributed geospatial systems: Tools (HadoopGist, Scala-Gist available as generic (open source) platforms for spatial analytics and the extended Resilient Distributed Dataset (RDD), can support spatial operations to access and provide real-time, inexpensive satellite imagery for accurate geospatial maps of affected areas to support decisions;
- call data record (CDR) modeling: Peoples' locations can be tracked in emergencies using radio tower locations and ubiquitous mobile phones. Location and movement (travel/walking) habit can be modeled through CDR to assist in relocation, settlement or easy distribution of relief materials;
- power or energy solution: provision of alternative energy (affordable solar power) solution setup, maintainable in conflict zones and situations. (This also provide ability to recharge mobile phones, power life-saving device or give lights in rural are as);
- logistics: DSS tools offers timely (logistic) intervention in getting resources to affected locations. Employed by relief agencies for community resilience in time of crises, practitioners with logistic capacitycan deploy this IS with other solutions to adapt consequences of catastrophic failures (such as solar-power power outages, fire extinguisher, bomb- detectors etc.);
- offline services and big data: using resource (such as AWS Snowball Edge, which is petabyte-scale data transport) with computer tool, 100 Terabyte (100TB) of data is transferrable and on-board storage plus temporary local cloud computing capabilities provided;
- digital identity: this technology offers many solutions to include easy identification of citizens and determination of services entitled. Documentation will also enable quick replacement if lost in crises period and storage enhanced by block-chain technology (data shared with others for safety and retrieval); and
- financial service inclusion: using the ubiquity of mobile phones, payments made in digital forms reduces stress and other challenges of theft or robberies. This is useful and could be aided by digital identity.

4.1 Evaluating IRE approach and AI methods

IRE constitutes information application for a variety of tasks and its methodologies evolves solutions that addresses many concerns affecting the society because Artificial Intelligence (AI) deals with helping machines find solutions to complex problems in a more human-like fashion. Information sourcing, retrieving and exploitation are increasingly offered to proffer solutions to real-life problems. As stated in the MDG, by 2030, legal identity must be provided for all. Nigeria as one of the nations is presently characterized with many humanitarian crises, far more reaching and becoming widespread in all states. Capacity building through STEM and TVET adoption should focus on both information-oriented analysis and process-oriented techniques for providing solutions, which can promote the economy. IRE and AI methods evolve socio-economic development when adequately harnessed.

Analysis in IE is data-oriented (Demurijian, 2008) approach and query mining inferencing is (AI) process-oriented. The duo is implemented in IRE and the methodologies are employed to develop user specified solutions as corroborated in Sadiku *et al.* (2017). IRE is vital as critical systems (such as health-care, aircraft control, telecommunications, ATM/banking, biotechnology, CAD/CAM, geographical information systems (GIS) and reservations) heavily depend on information to deliver. Therefore, women participation in these areas and many more STEM-related disciplines is a targeted approach towards gender-equality, which is a candid profitability factor for improved economy and strategized SDG-goal attainment.

4.2 Technology option justification for humanitarian crises

Technology approaches in both slow and fast crisis must focus on tools that impacted society. Responders should know how to apply them and focus would be on quick response rather than random experimentation. With women participation in IRE as men, greater productivity is realizable and gender-equality goal is attained. Though, gender is perceived as major factor of performance at different levels of academic pursuit, and studies conducted in Salikutluk and Heyne (2017) align masculine characteristics to science professionals and feminine to humanities, gender-balance will prove these assertions otherwise with TVET strategy and adequately harnessed IRE methodologies. Equally, as gender-equality does not connote rivalry but complementation, the more women in large/massive data handling characterized in deep-learning AI techniques, the more TVETs' objectives would impact socio-economic growth. Formulated technologies in this paper will help mitigate humanitarian crisis and increase community resilience if implemented by a strong association of men and women.

5 CONCLUSIONS

IRE methodologies are employed to develop ICT-technologies, which could serve as DSS tools to assist in handling humanitarian crises. Objective of using *TRQ* and *TkNN* algorithms in finding *k* nearest trajectories similar to defined ranges based on RangeQuery was achieved. Analysis and inferencing of given queries are very useful in many applications such as intelligent transportation systems (ITS) and advance pattern-mining queries. These approaches enable further information-related activities as sourcing, retrieval and exploitation using procedures of *partitioning*, *local-computation* and *global-computations*.

It is quickly suggested in line with Aderibigbe (2011) that, since TVET play key roles in human development and capacity building, its strategies should be targeted to avert gender-inequality and capacity-inadequacy problems associated with ICT and other disciplines. This is because, ICT is regarded as the wheel of development in developing nations. Therefore, more women impact in ICT, which had witnessed the birth of organizations like *Women in Artificial Intelligence (WAI), Women in Machine Learning (WiML), Nigerian Women in Information Technology (NIWIIT) and several others*, the general view of male students outperforming the females in STEM-related disciplines had been proved otherwise and encouragement of more women participating in STEM-related disciplines (through TVET strategies) will positively achieve the SDG goal of **gender-equality**. Women will be given more boost through collaboration with men to build more capacity, which is another feat that will rapidly enhance socio-economic growth and development.

It is also worth mentioning here that women (including girl child) should be mandated to participate in STEM-related disciplines. '**BEMORE**', an initiative of the first lady of Ondo State, Her Excellency, Mrs. Betty Anyanwu-Akeredolu, was initiated to train secondary school girls on science tech, ICT development and other entrepreneurial skills. After a boot camp, formidable organizations volunteered partnership and girls trained to design renewable energy systems and deploy IT solutions, which added value to the State's economy. The laudable project among her other numerous projects had empowered majority of the secondary school girls in Ondo State.

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