THE RELEVANCE OF INFORMATION COMMUNICATION TECHNOLOGIES (ICTs) IN AGROFORESTRY PRACTICES

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ABSTRACT
Heathcote (2000) posited that "Within half a century, computers and information technology have changed the world and affected millions of lives in ways that no one could have foreseen". The great impacts, contributions to knowledge, importance and economic achievements that have emerged from the fields of computer science (information science) and electronic engineering, in the 21st century, are revolutionary and mind boggling (Bamgbade,2011). This paper explores the extent to which ICT applications have improved agro-forestry practices and discussed areas of application such as forestry and environmental management, species identification, research publication, ICT in agroforestry education, plant pathology studies, wood anatomy, biometrics, Data management, modeling, analysis and mining

Keywords: ICTs, Agroforestry, Impact, Management, Computers, Practices and Applications.

1. INTRODUCTION

The relevance of ICT to agroforestry practices can be seen in the context of Mathematical and computational programming as applied in this domain for strategic planning. One of such computational based system is the SPECTRUM used by the United State government to carry out strategic planning in agroforestry. The system which evolved from an earlier system (FORPLAN) has the following key attributes:

Multi-resource modeling: The system provides a generic framework for modeling any resource. A basic configuration depends on user-defined analysis units, management actions, activities and outputs, resource coefficients, and economic information.

Spatial and temporal scales: Spectrum applications are not scale-specific. Up to 90 time periods of any length may be used to support analysis at relevant spatial and temporal scales.

Multiple options for mathematical programming: Spectrum supports numerous combinations of optimization techniques and objective functions. Optimization techniques include:

- Linear programming (optimization of a single criterion).
- Mixed-integer programming (optimization with categorical outcomes).
- Multi-objective goal programming (simultaneous optimization of multiple goals).
- Stochastic programming to account for random events such as fires, pest epidemics, and uncertainty about data.

Specifications for objective functions: Options for objective functions in traditional linear programming include maximizing or minimizing a single outcome or measure of performance. Objective Functions for goal programming include minimizing under-achievement of goals, minimizing over-achievement of goals beyond thresholds, or minimizing both. Two additional options for objective functions are MAXIMIN (maximizing the minimum level of occurrence for a critical resource) and MIN/MAX (minimizing the highest level of occurrence of an undesirable outcome).

Simulation of ecological processes and modeling natural disturbance:
Spectrum allows embedding simulation of ecological processes and modeling of natural disturbances by means of state, flow, and accessory variables in dynamic equations.
The Regional Ecosystems and Land Management (RELM) system extends the utility of Spectrum solutions by apportioning forest-wide, strategic planning solutions to tactical sub-units of the forest such as watersheds. Cumulative effects and connected actions can be analyzed both within and between sub-units, allowing planners to evaluate how alternative management scenarios affect neighboring units.

2. OTHER DOMAIN OF APPLICATION

2.1 Research Publication

Information dissemination is a prominent activity in any research institute as it is the means through which it could be adjudged whether it is living up to the mandate and purpose for which it was established. Also, research publications play a pivotal role in any academics environment, be it in a University, Research institute, or polytechnic Paper publication is a useful instrument through which research discoveries and breakthroughs are disseminated to the stakeholders.

However, publishing research papers in a manual format is attached with great difficulties and problems, which includes ineffective and inefficient delivery system of the journal as at when due, prone to natural disasters, lost, theft, mutilation. Sequel to the aforementioned problems, a software (FRIN –e JOURNAL: An Electronic Submission Platform for Research papers) has been developed in FRIN which would allow for easy electronic retrieval, storage and efficient research information delivery system. It will go along way to automate the existing manual journal with easy search tool and navigation properties, providing researchers, administrator and FRIN editors with separate interface with hands on functionality and notification capability also creating a proper record of subscribers and records of subscription. It is cost effective and is not regional bound.

2.2 Specie Identification

Although automated species identification for many reasons is not yet widely employed, efforts towards the development of automated species identification systems within the last decade is extremely encouraging; that such an approach has the potential to make valuable contribution towards reducing the burden of routine identification. A free specie identification software has been developed in Forestry Research Institute of Nigeria (FRIN) called "Design and Development of an expert system for Tree species identification"

There are many factors influencing the taxonomic impediment to the study of biodiversity. A major one being that the demand for routine identification in biodiversity studies extends beyond the available resources. In many spheres the volumes of plant or animal specimens that can usefully be obtained, particularly using modern sampling methods, vastly outstrip any capacity to identify this material. This has limited the progress in some aspect of biodiversity research.

These demands are likely to steadily increase as the proportion of previously un-described species in local, national or regional floras and fauna declines and as requirement or desirability of biodiversity inventories and other such survey grows. This has led to several solutions being proffered to reduce the burden of routine identification. One of the proffered solutions is automating the identification process in some way. This is generically referred to as Computer Assisted Taxonomy (CAT). However, the development and application of an automated approach to taxonomic identification has remained a minority interest till date. Among reasons for this are the notions that it is too difficult, too threatening, too different or too costly. It is most encouraging to know that despite these limitations, efforts towards the development of automated species identification systems have been progressive.

From the evidences witnessed in this area, it buttresses the present minority notion that the automation of species identification process is possible and achievable. A system that uses binary codes generated based on the morphological characters of trees to uniquely identify tree species has been developed. Though this is not the first time an attempt is made to automate species identification using their morphological characters, our approach is far simpler and less expensive to implement. For instance while previous approaches are centered round the need for a computerized pattern recognition system, ours does not require such. We were able to easily prove the effectiveness of the system by restricting our study to the over one thousand Nigerian Trees species. All a user need is a functional computer system, a ruler and personal ability to supply answers to the questions asked by the system and the tree identification process is complete.

2.3 ICT in Agroforestry Education

Information and communication technologies (ICTs) have the potential to enhance access, quality, and effectiveness in education in general and to enable the development of more and better teachers in Africa in particular. As computer hardware becomes available to an increasing number of schools, more attention needs to be given to the capacity building of the key transformers in this process, namely, teachers. While societies undergo rapid changes as a result of increased access to information, the majority of the school-going youth continue to undergo traditional rote learning. Very little is done to take advantage of the wealth of information available on the Internet. Whereas the processing of information to build knowledge is one of the essential literacy skills vital for the workforce in the 21st century, it is often overlooked in current educational practices.

The Computers for Schools Program appears to be doing valuable work and in the process has become an unwitting champion of ICTs in education. Its experiences are real, its challenges huge, and the lessons valuable for the future of a resource poor country such as Nigeria. In order to function in the new world economy, students and their teachers have to learn to navigate large amounts of information, to analyse and make decisions, and to master new knowledge and to accomplish complex tasks collaboratively. Overloaded with information, one key outcome of any learning experience should be for learners to critically challenge the material collected in order to decide whether it can be considered useful input in any educational activity. This is the basis for the construction of knowledge.

The use of ICTs as part of the learning process can be subdivided into three different forms: as object, aspect, or medium (Plomp, ten Brummelhuis, & Pelgrum, 1997).

a) As object, one refers to learning about ICTs as specific courses such as 'computer education.' Learners familiarize themselves with hardware and software including packages such as Microsoft Word, Microsoft Excel, and others. The aim is computer literacy.
b) As aspect, one refers to applications of ICTs in education similar to what obtains in industry. The use of ICTs in education, such as in computer-aided design and computer-aided agroforestry technology, are examples.
c) ICTs are considered as a medium whenever they are used to support teaching and learning.

The use of ICT as a medium is rare (Plomp, et al., 1997), in sub-Saharan Africa where the availability of resources is a major obstacle to the widespread integration of ICTs in education. In order to sustain what has already been done and expand into areas still unreached; the objective of this text is to elicit support for training in ICTs in Nigeria as in many other African countries because it is in a state of mild crisis. Sequel to this is the need to explore the use of ICTs in education, such as in computer-aided design and computer-aided agroforestry technology, are examples.

3. POSSIBLE AREAS OF ICT APPLICATIONS IN AGROFORESTRY

With the advent of ICT, Dutta and Jain (2003) note that ICT forms the "backbone" of several industries and is today a dominant force in enabling companies to exploit new distribution channels, create new products, and deliver differentiated value added services to customers. ICT is also an important catalyst for social transformation and national progress. Disparities in levels of ICT readiness and usage could translate into disparities in levels of productivity and, hence, different rates of economic growth. It is also important to observe that ICTs can lead to economic growth but not development.

The social exclusion of large groups of persons, especially women, children, and people living in rural areas, is a common phenomenon when adequate planning has not accompanied ICT exploitation. Education in Nigeria faces a number of problems. These problems include the shortage of qualified teachers, very large student populations, high drop-out rates of students and teachers, and weak curricula. All of these negative aspects result in poor delivery of education. The education crisis is worsened by the devastating effects of increasing poverty, a brain drain in the teaching community, budgetary constraints, poor communication, and inadequate infrastructure.

Technology is not new to education. However, contemporary computer technologies, such as the Internet, allow new types of teaching and learning experiences to flourish. Many new technologies are interactive, making it easier to create environments in which students can learn by doing, receive feedback, and continually refine their understanding and build new knowledge. Access to the Internet gives unprecedented opportunities in terms of the availability of research material and information in general. This availability of research material and information happens to both inspire and threaten teachers. ICTs are one of the major contemporary factors shaping the global economy and producing rapid changes in society. They have fundamentally changed the way people learn, communicate, and do business. They can transform the nature of education – where and how learning takes place and the roles of students and teachers in the learning process.

3.1 ICT Application in Agroforestry

Diagnosis & Design methodology is a methodology for the diagnosis of land-management problems and the design of agroforestry solutions. It was developed by ICRAF to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects. From on-farm research trials, more rigidly controlled on-station investigations, and eventual extension trials in an expanded range of sites. As this iterative D & D process provides a basis for prompt feedback and complementarities between different project components. By adjusting the plan of action as indicated by new information, the D & D process becomes self correcting. In an integrated agroforestry research and extension program, pivotal decisions are made in periodic meetings of the various project personnel who evaluate new results and revise the action plan accordingly. The process continues until the design is optimal and further refinement is deemed unnecessary.

3.2 Expert System in forestry management

Expert system applications in forestry began appearing in the late 1980s (Schmoldt and Martin 1986). Some examples include a diagnostic and risk assessment tool (Schmoldt 1987, Schmoldt and Martin 1989) for insect and disease outbreaks in red pine (Pinus resinosa), an advisory system providing stand prescriptions for deer and gFouse (Buech et al. 1989), a silvicultural system for managing red pine plantations (Rauscher et al. 1990), -and a system for diagnosing the hazard and risk of bark beetle outbreaks in Alaska (Reynolds and Holsten 1997). Numerous other expert systems were developed to assist with forest pest management, silvicultural prescriptions, and timber harvesting, among other things (Durkin 1993). Developed initially as stand-alone software, eventually expert systems were integrated with optimization, simulation, geographic information systems (GIs), and other technologies covered elsewhere in this text.

3.3 Fuzzy Logic network in forestry management

In the early years of knowledge-based system development, prevailing conventional wisdom held that such systems were best suited for very narrow, well defined problems (Waterman 1986). This is clearly reflected in the catalog of systems documented by Durkin (1993). However, the integration of fuzzy logic (Zadeh 1975a, 1975b, 1976) into knowledge-based systems in the early 1990s, as exemplified in systems such as a fuzzy version of CLIPS (Giarratano and Riley 1998) and NetWeaver (Miller and Saunders 2002) opened up new possibilities for applying knowledge-based methods. This marriage of technologies permitted application to much more general and abstract kinds of problems related to the management of natural resources, in general, and forest management in particular (Reynolds 2001a, 200 1 b).

3.4 GIS and Remote Sensing in Environmental Management

In the1960s,the Canadian department of forestry and rural development realized that they had one of the largest landmasses and among the largest collections of natural resources anywhere but its knowledge of the extent, quality and longetivity of the national resources was limited .Government planners also recognized that just to map such a large area would require more trained cartographers than were then available and recognizing that such a massive task would require far longer than they could allow if they wanted to develop successful management plans for their resources, they arrived at an essential conclusion, that there was a need for Canadian Geographical Information System (GIS).As it were, GIS functions optimally on the platform of computer science to implement or explore its set objectives. Accordingly, Rhind (1998) defined GIS as "a computer system for collecting, checking, integrating and analyzing information related to the surface of the earth". As it were, there is an ever increasing recognition of the need to perform large scale mapping and map analysis operations for a wide variety of traditionally manual tasks. Furthermore, forests see GIS (a computer based application) as an efficient management tool for their day –to-day operations

A wide variety of software applications are available to support decision making in forest management, including databases, growth and yield models, wildlife models, silvicultural expert systems, financial models, geographical information systems (GIS), and visualization tools (Schuster et al. 1993). Typically, each application has its own interface and data format, so managers must learn each interface and manually convert data from one format to another to use combinations of tools. Considering the scope of topics that may need to be addressed in a typical ecosystem management problem, and consequently the need to run several to many applications, manual orchestration of the entire analysis process can quickly become a significant impediment. LMS relieves this problem by managing the flow of information through predefined pathways that are programmed into its core component.

LMS integrates landscape-level spatial information, stand-level inventory data, and distance-independent individual tree-growth models to project changes on forested landscapes over time. The core component of the application coordinates the execution of, and flow of information between, more than 20 programs, including a variety of utilities for data management such as formatting, classification, summarization, and exporting.

Stand projections in LMS are performed with variants of the Forest Vegetation Simulator or FVS (Crookston 1997) or **ORGANON** (Hester et al. 1987). A variety of utilities report stand projection information in tables and graphs, and projection information can be delivered to the ArcView GIS (Environmental Systems Research Institute) for additional spatial analysis, or to the Stand Visualization System (SVS) or to the Envision landscape visualization system (McGaughey 1997). Both forms of output data can be valuable. In some cases, it is useful to analyze projection data further using a spreadsheet or statistical software, while other times it is most instructive to simulate the appearance of a stand to qualitatively assess spatial landscape features (e-g., scenic vistas).

Earth observation from space relies on radiation measured by sensors. The signal depends on the way radiation interacts with the atmosphere and the Earth's terrestrial surface. The complexity of the interaction has promoted the development and use of empirical methods (e.g. vegetation indices). Most of these are based on quantitative, statistical relationships applied to a few images, which limits their robustness and use over large areas. Radiative transfer models, using complex mathematical methods, simulate and provide insight into the radiation interaction processes for varying vegetative parameters. Remote sensing imaging spectrometers have evolved with respect to larger spectral resolution imaging spectrometers (e.g. NASA's AVIRIS, NASA's Hyperion on EO-1, Itres' casi, HYMAP, AISA), increased signal-to-noise ratios, 12-bit (and higher) quantization, and multi-directional sampling capabilities (e.g. ESA's CHRIS PROBA). These improvements have stimulated the development of better models and opened up new prospects for retrieval of more detailed environmental information from these advanced sensors . Physical-based, quantitative canopy models compute vegetation canopy reflectance given leaf and canopy parameters (chlorophyll content, water content, leaf area index, etc.), a selected sun-target-sensor geometry, and information about the background (e.g. soil).

Canopy models can be used in direct (forward) mode to build new vegetation indices optimized for a particular sensor. Moreover, such models can be inverted against measured reflectance data to derive surface biophysical and structural parameters such as leaf area index (LAI), fraction of photosynthetically active radiation (fPAR), and vegetation fractional cover, which are used by ecologists to monitor the status and quantify the influence of vegetation. In contrast to multi-spectral sensors, hyperspectral sensors can produce quantitative estimates of canopy biochemical properties (such as chlorophyll and nitrogen concentrations).

Classification of hyperspectral imagery yields not only higher accuracy in land-cover characterization, but also of species recognition when compared to traditional remote sensing data sources such as Landsat. Forest biomass and carbon have been estimated employing both multi-sensor techniques and AVIRIS data using partial least squares (PLS) regression. Estimates of the chemical concentrations (chlorophyll, nitrogen, lignin, water content) of forest canopies can be made using hyperspectral data. Canopy models were used to simulate hyperspectral top-ofcanopy reflectance values for analysis of various biophysical and biochemical factors affecting canopy reflectance. Recently, canopy models have been employed to infer quantitative information from hyperspectral data on canopy structure and foliage biochemistry, such as LAI, leaf/needle chlorophyll content, and foliage water content. Hyperspectral imagery and canopy models were also used to analyze biological invasion, biogeochemical change and nutrient availability in tropical ecosystems.

Very high spectral and spatial resolution imaging spectrometer data were used in Malenovsky et al.to separately assess sunlit and shaded crowns of a Norway spruce canopy and quantify the impact of woody elements (e.g. trunks, first order branches and small woody twigs) in turbid media modeled cells using the 3-D radiative transfer model DART to further refine the retrieval of forest relevant ecosystem parameters. These land ecosystem information products can be used in forest disaster detection, invasive species mapping, Kyoto Protocol information products, monitoring forest health, ecosystem protection, and global change.

4. CONCLUSION

The relevance and application of ICT to Agroforestry practices in the 21st century is of tremendous importance. There are still more areas where ICT would be applicable in agroforestry which are yet to be discovered, but in the immediate future. Virtually, all other human endeavours have come to know that the benefits of ICT is far outstripped its disadvantages. It is therefore suggested that ICT should be a tool that all professions should embraced**.**

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ADAPTIVE GENETIC ALGORITHM FOR STUDENTS' ALLOCATION TO HALLS OF RESIDENCE USING ENERGY CONSUMPTION AS DISCRIMINANT

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ABSTRACT
Enjoying the benefits of Distributed Generation (DG) is consequent on its flexibility and ability for control. Incorporating Distributed Energy Resources (DERs) into existing power grid through a Virtual Power Plant (VPP) in a bid to decentralizing power generation by generating at load centers provides a frame work for influencing its operation. This control via software thus offers us an opportunity in exploiting the varied benefits DG seeks to offer. This paper thus examines such exploitation of DG in Independence Hall, in the University of Ibadan. In exploiting this benefit, the controllability of the DG and its subsequent upgrade is used in influencing the allocation of students into Independence Hall. Constraints such as hall size (minimum and maximum), per unit and total hall allocation in terms of energy and the difference between the cost of upgrade and energy savings are used in feeding a Genetic Algorithm (GA) in generating varied options from which choice can be made based on prevailing circumstances.

Keywords: genetic algorithm, distributed generation, distributed energy resources, virtual power plant, exploiting.

1. INTRODUCTION

The University of Ibadan has in recent years seen an upsurge in the number of students' application and subsequent admittance into the varied disciplines the University offers. This rise no doubt yields a concurrent increase in the number of students, *'**freshers**', which* are being allocated to the halls of residence scattered within the University Community. In trying to manually allocate students to residential halls, a lot of problems are being faced by the Management Information System (MIS) Department of the University. Adequately allocating eligible fresh students, reserving adequate bed spaces for eligible 'stale' students, ensuring that available facilities like kitchenettes, bathrooms, cafeteria, butteries etc. are not overstretched, creating a balance between 'fresh' and 'stale' students, ensuring an even distribution of bed spaces among the different categories of 'stale' students, ensuring that the prescribed energy allocation to each hall is not exceeded etc. are some of the criteria used in students' allocation. The daunting enormousness of this task thus presents a challenge to the University.

As the University grapples with this enormous task of students' allocation to residential halls, reducing its Green House Gas (GHG) Emissions by sourcing an increasing part of its energy from alternative energy sources (renewables) like Photovoltaic (PV) arrays, wind turbines, micro hydro and biomass is paramount. As surmised by Odubiyi [5], demand will continue to outstrip supply (in the short to medium term), hence sourcing for alternative energy sources becomes imperative [2].

As posited by Monyei [2], University of Ibadan in meeting this objective has been installing a lot of stand-alone solar inverter systems while exploring the feasibility of incorporating wind, hydro and biomass in a hybrid system. Their stochastic nature albeit, a proposed incorporation of Virtual Power Plants (VPPs) to even out the discrepancies between demand and supply and aggregate available Distributed Energy Resources (DERs) has been proposed [2] [6] [7]. One reason being put forward though for poor investment in this proposed option is cost. The University Management opines that with insufficient allocation it is constrained to evenly distribute this scarce resource (money) among relevant projects within the University Community.

It further posits that it is incapacitated in increasing its annual generation from renewables which is key to reducing the contribution of fossil fuels to the University's power generation. In seeking to proffer a solution to the plethora of problems confronting the University Management, Artificial Intelligence (AI) is used. The advent and popularization of stochastic evolutionary methods like Genetic Algorithm (GA) and Simulated Annealing (SA) is made possible due to their being able to exit a local minimum and reach a global optimum in optimization problems.

The solution presents the University constraints in form of equations. In optimizing the equations, GA is used in providing initial values, while component parts of the equations are optimized using individual constraints imposed on them. In exploring and exploiting the benefits of GA, multiple possible solutions are generated based on predefined cost functions.

2. GENETIC ALGORITHM

As posited by Yildiz and Ozturk [8], the inefficiency of traditional methods in solving complex nature problems has forced researchers in evolving new approaches. This has led to new approaches (e.g. evolutionary algorithms (EA), GAs, Simulated Annealing (SA), ant colonies etc.) in the area of optimization (Pengfei et al [1] define optimization as the process of making something better) research.

Nwaoha et al [4] define GA to be an optimization and search technique based on the principles of genetics and natural selection. This view is further reified by Pengfei et al [1] who opine that GA is an optimization algorithm intended to mimic some of the processes observed in natural selection. [4] further posit that GA is a stochastic search technique based on the mechanism of natural selection and natural genetics.

GA was first introduced by John Holland in the early seventies and was popularized by one of his students, Goldberg who was able to solve a difficult problem involving the control of gas-pipeline transmission in his dissertation [4] [1]. GAs are based on Darwin's Evolution Theory that individuals better adapted to their environments are the ones which effectively reproduce [3].

From the foregoing therefore, GAs as stochastic search algorithms basically iterate through a population mimicking Darwin's Evolution Theory, eliminate unfit species (based on predefined fitness functions or objectives), reproduce off-springs (amongst fittest selected parents) and mutate the new population (by introducing traits in their genes).

In designing a GA code therefore, a population needs to be defined (fig. 2). This sample space provides the environment for the activities of the GA. In defining the sample population, different methods could be used depending on the problem formulation and choice of the designer – binary, continuous, steady-state and multi-objective [4]. For the problem at hand, the binary GA method is used because of its ease of programming and ability to constrain its values to be within limits while generating a sample population. Thereafter, a fitness function is defined. This fitness function provides the GA intelligence in screening out unfit chromosome strings from the population (fig. 4) or in the eventual selection process.

Each chromosome string (fig. 3) corresponding to a solution is tested using the fitness function as a discriminant and their results are collated. Those with values coalescing around zero (optimal result) are considered better answers while those with values further dispersed from zero are considered poorer solutions (fig. 5). Elitism as used in the flowchart (fig. 1) means the selection of the top best results, those with results closest to zero. In filling the now depleted population, cross-over operation (fig. 6) is performed between the elitist solutions to generate off-springs who are going to compete with their parents in the next generation. Mutation operation is performed (fig. 7) to alter the gene construct of selected chromosomes in order to prevent the program from getting stuck in a local minimum.

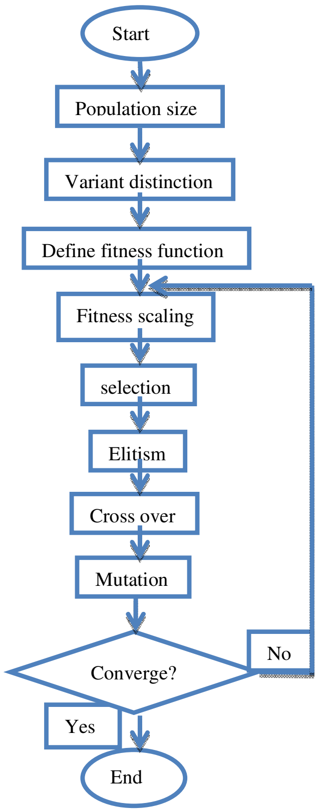

Fig. 1: flow chart of proposed GA

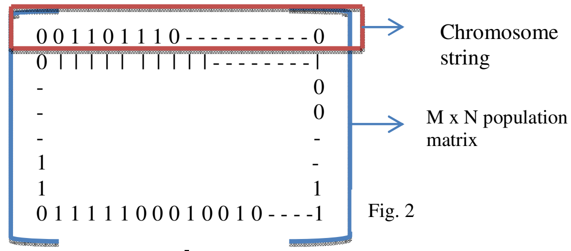

Fig. 2

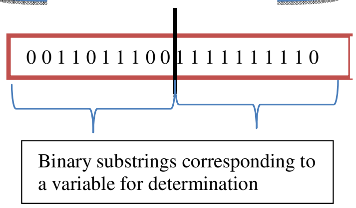

Fig. 3

Chromosome string	Penalty
00110111001111111110	2
01000001001110000111	0
11110001100000010010	10
00000100100000111111	-3
11111100100100000010	5
10000100111101010110	19
00100110111010101110	6
11010000000001001101	23

Initial population matrix with corresponding penalty

Fig. 4

Chromosome string	penalty
00000100100000111111	-3
01000001001110000111	0
00110111001111111110	2
11111100100100000010	5
00100110111010101110	6
11110001100000010010	10
10000100111101010110	19
11010000000001001101	23

Elitist chromosomes with the lowest penalty

Chromosomes with penalty ranked

Cross-over point

Fig. 5

Chromosome string	Penalty
00000**00100000111111**	-3
01000001001110000111	0
00110**11100111111110**	2
11111 00100100000010	5
00000**11100111111110**	1
01000 00100100000010	7
00110**00100000111111**	54
11111001001110000111	9

Elitist parents and off-springs

Elitist parents in new matrix

New off-springs after elitist parents have mated

Fig. 6

Chromosome String	Penalty
00000100100000111111	-3
00000011101110000111	0
01111111001111111110	2
11111101100100000010	5
00000111000111111110	1
01000100100100000010	7
00100100100000111111	54
11111001001110000110	9

Fig. 7

Mutated bit of chromosome

3. DERIVATIVES

Total power consumed by fresh students per iteration is given as:

$$T_{pfi} = \sum_{i=1}^{x} (b_{mi} * k) \text{ in kilowatts} \quad (1)$$

Total power consumed by 'stale' students per iteration is given as:

$$T_{psi} = \sum_{i=1}^{y} (b_{ni} * k) \text{ in kilowatts} \quad (2)$$

Total power from the DG units per i^{th} iteration is denoted as P_{dgi} and is given as:

$$P_{dgi} = \sum_{i=1}^{z} (e_i) \text{ in kilowatts} \quad (3)$$

Total power consumed per iteration is given as:

$$T_{pi} = \sum_{i=1}^{n} (b_i * k) = \sum_{i=1}^{x} (b_{mi} * k) + \sum_{i=1}^{y} (b_{ni} * k) \text{ in kilowatts} \quad (4)$$

Estimated energy savings per i^{th} iteration is given as:

$$T_{si} = (P_{dgi} + P_{gi} - T_{gi}) \text{ in kilowatts} \quad (5)$$

Fixed investment in increasing the capacity of the DG yearly is given as T_f in naira. The percentage contribution of new students is denoted by F_c (%).

The percentage contribution of returning students is denoted by F_r (%).

Fixed power from the schools grid per i^{th} iteration is given as P_{gi} in kilowatts.

Grid contribution per i^{th} iteration is given as P_{gc} in Kilowatts.

Where:

n denotes the total number of students that are allocated to the hall per run time.

k denotes the average power consumption per student in kilowatts.

x denotes total number of fresh students per i^{th} iteration.

y denotes total number of 'stale' students per i^{th} iteration.

z denotes total number of DG units per i^{th} iteration.

e denotes the Kilowatt rating of each DG unit per i^{th} iteration.

b_{mi} represents the i^{th} fresh student per iteration.

b_{ni} represents the i^{th} 'stale' student per iteration.

b_i represents the i^{th} total number of student per iteration.

For every i^{th} iteration, the GA code based on the hall constraints given subsequently generates x and y values respectively. For every x and y value generated, the contributions of the 'fresh' and 'stale' students in defraying the investment in increasing the DG capacity are computed using the F_c, F_r and T_f supplied. The contribution of the grid (P_{gci} in kilowatts) is the shortfall of the DG's contribution (P_{dgi} in kilowatts) to meeting the total energy consumption estimate (T_{pi} in kilowatts) for every i^{th} iteration.

$$q_{min} \le x \le q_{max} \quad (6)$$

$$w_{min} \le y \le w_{max} \quad (7)$$

$$x + y \le h_{max} \quad (8)$$

$$x + y \ge h_{min} \quad (9)$$

$$q_{min} + w_{min} \ge h_{min} \quad (10)$$

$$q_{max} + w_{max} \le h_{max} \quad (11)$$

Where:

q_{min} denotes the minimum number of 'fresh' students that are to be allocated to the hall.

q_{max} denotes the maximum number of 'fresh' students that are to be allocated to the hall.

w_{min} denotes the minimum number of 'stale' students that are to be allocated to the hall.

w_{max} denotes the maximum number of 'stale' students that are to be allocated to the hall.

h_{min} denotes the minimum number of students to be allocated to the hall.

h_{max} denotes the maximum number of students to be allocated to the hall.

The GA thus provides us with options and the ability to choose from a variety of possible solutions based on prevailing situations. In presenting this flexibility and choice the GA proffers, plots of energy savings from the grid and corresponding hall utilization (both in percentage and actual values) are thus presented. Also, snippets of the results of running the code are shown with the varied options there are to choose from.

In generating these results, Mat lab (Matrix Labouratory) R2009a has been used extensively in compiling and executing this code (fig. 8 and fig. 9). The powerful nature of this programming software and its ease of programming coupled with its general acceptability make it the ideal software for executing this work. Mat lab also allows for graph plotting (fig. 10) in various formats by manipulating data and executing simple codes. This version of Mat lab was installed and run on a laptop computer with 4 GB DDR3 Memory, 500GB HDD and an Intel Core™ i3-380M Processor. It achieved a fast run time with no hitches for the different times the program was executed. The interactive nature was achieved by running the program from an M-File.

```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

Copyright of G.C.M.
Adaptive GA for students' allocation to halls of residence using energy as discriminant
Please input current year: 2013
Please input Maximum Hall Capacity: 1000
Please input Minimum Hall Capacity: 500
Please input Base Energy allocation to Hall(KW): 400
Please input current DG contribution (KW): 40
Please input current grid contribution (KW): 360
Please input number of years to forecast: 10
Please input freshers contribution to green levy (%): 55
Please input stallites contribution to green levy (%): 45
Please input fixed naira investement per year: 500000
Please input estimated DG growth: 10
fx Please input number of generations per year: 10
```

Fig. 8: a snippet of the Matlab Environment on running the interactive M-File

```
     353.00       479.00       779.04       469.73       161.52        94.32      238.48

     355.00       509.00       774.65       442.04       148.72        94.32      251.28

     291.00       510.00       945.02       441.18       173.92        94.32      226.08

     355.00       495.00       774.65       454.55       154.32        94.32      245.68

     355.00       511.00       774.65       440.31       147.92        94.32      252.08

     355.00       511.00       774.65       440.31       147.92        94.32      252.08

generation: 10
   'freshers'   'stalites'      'fc'         'sc'      'savings(KW)'  'DG(KW)'   'Grid(KW)
     355.00       511.00       774.65       440.31       147.92        94.32      252.08

     355.00       503.00       774.65       447.32       151.12        94.32      248.88

     355.00       503.00       774.65       447.32       151.12        94.32      248.88

     339.00       509.00       811.21       442.04       155.12        94.32      244.88

     339.00       511.00       811.21       440.31       154.32        94.32      245.68

     354.00       511.00       776.84       440.31       148.32        94.32      251.68

     355.00       471.00       774.65       477.71       163.92        94.32      236.08

     355.00       493.00       774.65       456.39       155.12        94.32      244.88
```

Fig. 9: a snippet of the result of executing the M-File

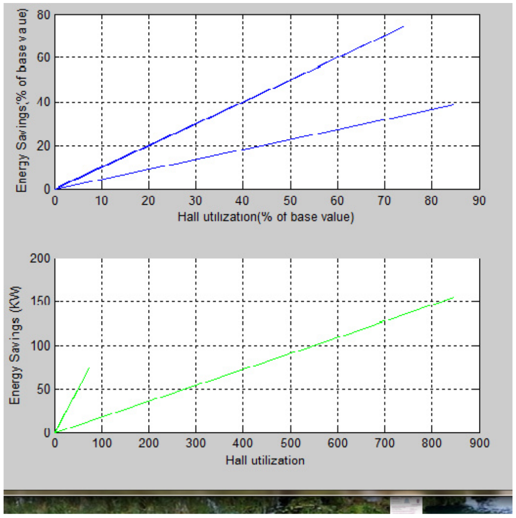

Fig. 10: Generated values for one run of the M-File

4. RESULT AND CONCLUSION

As can be gleaned from fig. 8, the administrator is expected to supply just a minimum of details while the GA is left to generate values (fig. 9 and fig. 10) based on constraints imposed. In generating these values, the GA also provides the administrator with corresponding results such as the contributions of the students both 'fresh' and 'stale', the estimated energy saved from the grid (in kilowatts), the current DG capacity (in kilowatts) and a graph plot of energy savings against hall utilization thus giving a holistic view of the results of making any choice. It thus saves time and allocation drudgery while reducing errors of over and under allocation. The adaptive nature of the GA is in its ability to generate values according to the constraints imposed screening out values that do not meet the preset requirements.

From the foregoing therefore, the use of this adaptive GA is highly recommended for the MIS division of the University of Ibadan (initially as a test-run to better adapt the GA or incorporate neural networks in making the program more intelligent).

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