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Design and Implementation of a Model for Population Forecasting

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Abstract This paper tends to develop a model for population forecasting. With the objective to analyze the features of existing population census in Nigeria and carry out a comparative difference between the manual calculation system and the computerized system design. The methodology and assumption used for developing population forecast model where developed with Fund Growth model of population. The accuracy of the census Bureau's forecasting efforts apparently has improved during the past two decade, this work is done with the aim of studying all the processes in manual forecasting on population census, with faster, easier, accuracy and efficiently, in the course of achieving these objectives, different data gathering tools used to gather information from National population census commission (N.P.C) and journals ,the growing literature on population forecasting was examined with curious paradox, despite continuing refinements in the specification of models used to represent population forecast, a detailed literature review on the existing literatures on the population census and forecasting were reviewed, a stated objective were drawn up and how to combat the myriad problem and designed of a pro-active population forecast to avert this short fall were implemented utilizing a model population conclusively, the model for population census forecasting can predict future population at burst time and efficiency and reliability at given time.

Keywords Population Census, model forecasting

1. Introduction

Population is often used simply to refer to the total number of a given piece or a set of item from which samples are taken for statistical analysis. Population census is the procedure of systematically acquiring and recording information about the members of a given population. It is a regularly occurring and official count of a particular population, the term is used mostly in connection with national population and housing censuses; other common censuses include agriculture, business, and traffic censuses. In the latter cases the elements of the 'population' are farms, businesses, and so forth, rather than people. The United Nations defines the essential features of population and housing censuses as "individual enumeration, universality within a defined territory, simultaneity and defined periodicity", and recommends that population censuses be taken at least every 10 years [1].

A prediction or forecast is a statement about the way things will happen in the future, often but not always based on experience or knowledge. While there is much overlap between *prediction* and *forecast*, a *prediction* may be a statement that some outcome is expected, while a *forecast* may cover a range of possible outcomes, although guaranteed information about the information is in many cases impossible, prediction is necessary to allow plans to be made about possible developments. Statistical agencies traditionally deal with the uncertainty of forecasting population variables by producing two or more forecasts of fertility or mortality (or both), and then calculating a range of forecasts. For instance, Statistics Norway expects the number of children aged 6–12 in

Norway in 2010 to be between 401,000 and 436,000, depending on whether fertility is low or high — that is, on whether women will have an average of 1.5 or 2.1 children, respectively, in 2010 [2].

A population forecast is an estimate of future population growth. It is based on a review of historic population growth and assumptions about future demographic and economic trends, Census can be contrasted with sampling in which information is obtained only from a subset of a population, census data is commonly used for research, business marketing, and planning, as well as a baseline for sampling surveys. Census counts are necessary to adjust samples to be representative of a population by weighting them as is common in opinion polling. Similarly, stratification requires knowledge of the relative sizes of different population strata which are derived from census enumerations. In some countries, census data are used to apportion electoral representation [3]. Forecasts of the size and structure of the population are central to social and economic planning, from the provision of services in the short term to policy development in the long term. Not least of the demographic challenges facing developed countries is the rapid ageing of the population. Already developed-country populations are experiencing unprecedented large elderly proportions. The major driver of this ageing process is the fertility fluctuations of the past, notably the post-war baby boom coupled with the low fertility of recent times, but declining mortality is also significant. One response to population ageing and the attendant shortage of labour to provide for the elderly has been an increase in immigration to 'replace' or make up for past shortfalls in births [4]. This paper tends to design and Implement an improve model for population forecast

2. Literature Review

[5] Propose Models allow a better understanding of how complex interactions and processes work. Modeling of dynamic interactions in nature can provide a manageable way of understanding how numbers change over time or in relation to each other. Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species. [6] Population models are used to determine maximum harvest for agriculturists, to understand the dynamics of biological invasions, and have numerous environmental conservation implications. Population models are also used to understand the spread of parasites, viruses, and disease. The realization of our dependence on environmental health has created a need to understand the dynamic interactions of the earth's flora and fauna. Methods in population modeling have greatly improved our understanding of ecology and the natural world. Population refers to the universe of human beings with distinct individual /group characteristics such as total number (i.e. size), composition (age, sex, marital status, and literacy) distribution in space and changes in these attributes. In population studies uses is increasingly being made of non-demographic events to explain and predict variations in demographic variables such as birth rates, death rates, migration rates, the composition and size of the population. [7] A population census is the counting of all the people living in a country at a particular time. It collects information on the size, distribution, composition and other social/economic characteristic of population, (National Population Commission 2005). Population forecasting is a future estimate indicating how the population size will increase arbitrary. It is therefore what the future population would be. Population projection is based upon reasonable assumption on the future course of fertility, mortality, migration [7]. Population forecasting are calculations based on models which show the future development of a population when certain assumptions are made about the future course of population change, usually with respect to fertility, mortality and migration. They are in general purely formal calculations, developing the implications of the assumptions that are made. [8] A population model is a type of mathematical model that is applied to the study of population dynamics. One of the most basic and milestone models of population growth was the logistic model of population growth formulated by [9]. The logistic model takes the shape of a sigmoid curve and describes the growth of a population as exponential, followed by a decrease in growth, and bound by a carrying capacity due to environmental pressures, [10]. Population modeling became of particular interest to biologists in the 20th century as pressure on limited means of sustenance due to increasing human populations in parts of Europe were

noticed by biologist like Raymond Pearl). [11] A population is a summation of all the organisms of the same group or species, who live in the same geographical area, and have the capability of interbreeding , the population of a certain species in a certain area is estimated using the Lincoln Index. The area that is used to define a sexual population is defined as the area where inter-breeding is potentially possible between any pair within the area. The probability of interbreeding is greater than the probability of cross-breeding with individuals from other areas. Under normal conditions, breeding is substantially more common within the area than across the border.[12] proposed Application of machine learning algorithms for population forecasting. In this study, different machine learning algorithms were used to forecast population; extreme gradient boosting, CatBoost, linear regression, ridge regression, Holt-Winters, exponential, autoregressive integrated moving average (ARIMA) and prophet prediction model. [13] proposed Population Forecasting System Using Machine Learning Algorithm. In every nation, there has been a platform to ascertain its citizens' exact number, population growth rate and make plans and decisions using the population information. The government spent a lot of resources on census enumeration. Unfortunately, in Nigeria, census enumeration has been embroiled in controversies. To overcome these problems, the existing systems face, the researchers have designed and developed a population forecasting system using a machine learning algorithm. [14] proposed Regional Population Forecast and Analysis Based on Machine Learning Strategy. : Regional population forecast and analysis is of essence to urban and regional planning, and a well-designed plan can effectively construct a sound national infrastructure and stabilize positive population growth. **[15]** proposed An Overview of Population Projections— Methodological Concepts, International Data Availability, and Use Cases. Population projections serve various actors at subnational, national, and international levels as a quantitative basis for political and economic decision-making. **[15]** proposed Bayesian cohort component population forecasts. they explore the use of Bayesian methods for projecting the United Kingdom's age- and sex-specific population. We first argue that a Bayesian approach is a natural framework for incorporating various forms of uncertainty in probabilistic projections. From research, it was observed that the existing model lack precious due to analog nature of the system. With the proposed system, population forecasting will be accurate and timely

3. System Analysis

The system design model is a logical representation, which abstracts the features of a real system. It involves the design and the use of models to predict the characteristics of any system after the analysis is carried out to achieve or realize the goals of the analysis. It is particularly valuable when the designed system or prototype is large and complex. If a model is properly designed the result obtained from it may be use within a high degree of confidence in predicting the performance of the prototype. Models are widely used in the designing of engineering systems. In this vain the Model-view-controller **(**MVC**)** architecture (see figure 1) will be use in the analysis and design of the proposed system because of the decoupling that this architecture or design pattern/process offers.

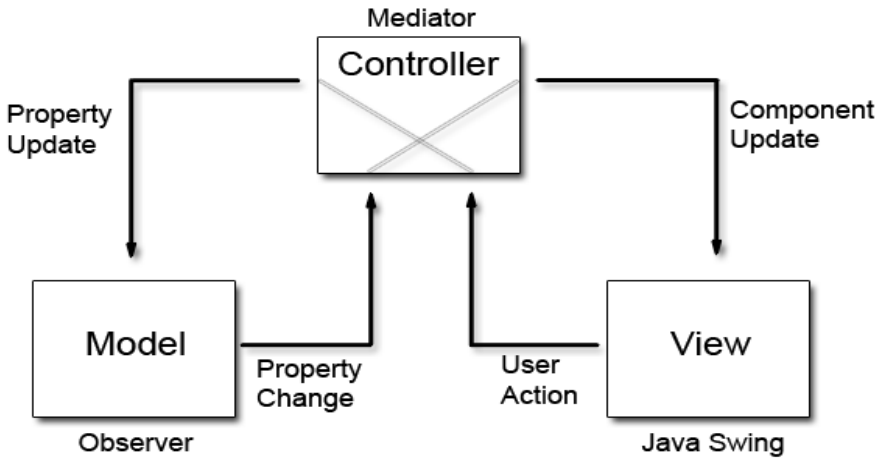

Figure 1: Model-View-Controller design patterns

Model-view-controller (**MVC**) is a design pattern used to isolate business logic from the user interface. Using MVC, the Model represents the information (the data) of the application and the business rules used to manipulate the data, the View corresponds to elements of the user interface such as text, checkbox items, and so forth, and the Controller manages details involving the communication between the model and view. The controller handles user actions such as keystrokes and mouse movements and pipes them into the model or view as required.

A typical MVC patterns instantiation looks something like the following; the controller takes an interface to the view and model. It is important to know that the view will typically interact with the controller if it needs notification of events which are fired via the view (such as a button click).

4. Analysis of the Existing System

The existing system used in population forecast is based on pen and paper, also it consists of boring process that makes it expose to numerous human prone errors that is inevitable in the final results obtained. This could lead to taking bad decisions that involves policy formulating that affects the population and areas that is applied to in adverse ways. The statistical derivation of formulae used in the population forecast model, and applying this formulae could lead to error on the part of the human involve which can be adverted using a computer program designed for this purpose, this is what the proposed computer software tend to solve.

5. Analysis of the Proposed System

The proposed system is computer based population forecasting system that uses a fund growth model to forecast population figure, all the population forecasted takes initial values from year 2006, population forecast figures is dynamically generated depending on the input the system gets from its user, the system ensures that the user enters correct values by validating the user inputs, the user inputs bad inputs the system will alert the user through a dialog box

6. Model Formulation

Methodological developments have also contributed to the production of more reliable Forecast than in the past. Further, the application of computer technology has cut the cost and time required for producing forecast and has widened the Scope and refinements in the application of complex statistical and modeling Operations.

A demographic forecast model called the natural fund growth rate was used to forecast the population residing in Nigeria, natural fund growth rate model were developed forecasts to predict future populations for ten years as outcomes of the life events that occur over time these events are comprised of births, deaths, and migrations. Thus, an area's population grows when births outnumber deaths and when more people move into the area than leave it. These events occur more often in certain age groups, For example, people tend to move around the most when they are in their 20s, or the elderly have lower chances than people in their 40s to survive over the next five years. Applying appropriate age- and gender-specific rates of birth, death and migration to the existing population model produce its future population.

Natural fund growth rate model of forecasting population depends on the availability of accurate data on the age and gender composition of an area's population. The most precise information about population age structure in an area is usually provided by the most recent Nigeria. Rates of life events are applied to the known population The existing population structure mostly determines the future population composition of the area, but it may change slightly depending on age-specific migration rates predicted for the future. Trends detected in historical and recent data, such as housing, land use, employment, and school enrollment data help to determine these future migration rates.

Forecasting a known population and its age distribution enables appropriate adjustments to be made to the model so that the forecasted population becomes aligned with the actual population and ensures the accuracy of the model's forecast. During each ten-year interval, a certain number of live births occur to the women in childbearing ages. To calculate the number of newly born residents of the Country and its larger sub-areas, age-specific fertility rates were applied to the numbers of women in childbearing (under age 20, 20 to 24, and so on up to 45-49 years). Fertility rates indicate how many children women in a given age group are likely to give birth to during each ten-year period. Forecast period. In addition, migration patterns are greatly influenced by the local economy and by housing growth in the area, both current and assumed. When making the final adjustments to the net migration rates, consideration also was given to plan for future development in the region.

We analyzed population of fund growth rate which is filtered by a model of the form.

$P(t) = Po\,(1 + R/100)t$ ……..$equation$ (1)

Po=initial population

t=time ie years

R=rate of growth of population

R=[birth rate + migration]-[Death rate]

Let birth rate denoted by B

Let migration of population denoted by M

Let death rate be denoted by D

$R = (B + M) - D$ …….. (2)

Substitute for R in Eq (1)

$P(t) = Po\,(1 + (B + M) - D)\,/100))t$ …… equation (3)

Based on the rate of birth, migration and death rate are given and in constant growth rate, we can have the population forecast as stated in equation (3) above

Nigeria has experienced a population explosion for at least the last 50 years due to very high fertility rates, quadrupling its population during this time. According to the United Nations, the population of Nigeria will reach 390 million by 2050. In 2100, the population of Nigeria will reach 730 million. According to the United States Census Bureau, the population of Nigeria will reach 402 million by 2050. Nigeria will then be the 4th most populous country in the world.

Table 2: Vital Statistics of Nigeria

Population growth rate	2011 est.	1.9 % per year
Birth rate	2011 est.	35.51 births/1,000 population
Birth rate, boys	2011 est.	18.27 births/1,000 population
Birth rate, girls	2011 est.	17.24 births/1,000 population
Death rate	2011 est.	16.1 deaths/1,000 population
Net migration rate	2011 est.	-0.1 migrants/1,000 population
Total fertility rate	2011 est.	4.73 children born /women
Infant mortality rate	2011 est.	91.54 deaths/live births
Infant mortality rate, boys	2011 est.	97.42 deaths/1,000 live births
Infant mortality rate, girls	2011 est.	85.31 deaths/ 1,000 live births

Table 3: Summary of Nigeria Population

Total population	2011 est.	155,215,573 persons
Male population	2011 est.	79,114,137 persons
Female population	2011 est.	76,101,436 persons
Density of population	2011 est.	168.0 persons per km^2
Sex ratio of total population	2012 est.	1.040 male/female
Sex ratio at birth	2012 est.	1.060 male/female
Sex ratio under 15 years old population	2012 est.	1.046 male/female
Sex ratio of 15-64 years old population	2012 est.	1.041 male/female
Sex ratio of 65 years and over population	2012 est.	0.936 male/female
Population in urban areas	2010	50.0 % of total population
Rate of urbanization	2010-15 est.	3.5 % per year
Population in rural areas	2010	50.0 % of total population
Population under 15 years old	2012 est.	40.9 % of total population
Male population under 15 years old	2012 est.	41.1 % of male population
Female population under 15 years old	2012 est.	40.8 % of female population
Population 15-64 years old	2012 est.	55.9 % of total population
Male population 15-64 years old	2012 est.	56.0 % of male population
Female population 15-64 years old	2012 est.	55.9 % of female population
Population 65 years and over	2012 est.	3.1 % of total population
Male population 65 years and over	2012 est.	3.0 % of male population
Female population 65 years and over	2012 est.	3.3 % of female population
Total median age	2012 est.	19.2 years
Male median age	2012 est.	19.2 years
Female median age	2012 est.	19.3 years
Life expectancy at birth, total	2011 est.	47.6 years
Life expectancy at birth, male population	2011 est.	46.8 years
Life expectancy at birth, female population	2011 est.	48.4 years

7. Implementation for Population Forecast

The fund growth model stated in equation (2) above will be adopted for the implementation of the population forecast; this written as $P(t) = P_o (1+R/100)^t$

To estimate the errors of population, we use the following;

$$Error = Actual\ value\ of\ population - Estimated\ value\ of\ population$$

$$Percentage\ Error = [(Actual\ value\ of\ population - estimate\ value\ of\ population)\ x\ 100)]/(Actual\ value\ of\ population)$$

a. Population Forecast for 5 years between 2006 and 2011

$R = (B + M) - D) /100$

$P(t) = Po [1 + (1+R)]^t$

$R = [(B+M) - D]/100 = 1.9/100$

$P(t) = P_o [1 + (B+M) - D]^t$

$P = P_o [1+ (B + M)]^t$

$155,215,573 = P_o [1 + 1.9/100]^5$

$155,215,573 = P_o [1 + 0.019]^5$

$155,215,573 = P_o [1.019]^5$

$P_o = 155,215,573/(1.019)^5$

$P_o = 155,215,573/1.098679244$

$P_o = 141274693.1$

$P = P_o = [1 + r]^t$

$P = 140,003,542 [1 + 0.019]^5$

$P = 140,003,542 [1.019]^5$

$P = 153,818,985.7$

Year	Nigeria (actual)	Nigeria (estimated)
2011	153,818,985.7	155,215,573.3

b. Population Forecast for 10years between 2006 and 2016

$P = P_o = [1 + r]^t$

$P = 140,003,542 [1 + 0.019]^{10}$

$P = 140,003,542 X [1.019]^{10}$

$P = 168997726.93$

3.6.3 Population Forecast for 20years between 2006 and 2026

$P = P_o = [1 + r]^t$

$P = 140,003,542 [1 + 0.019]^{20}$

$P = 140,003,542 X [1.019]^{20}$

$P= 203996493.90$

8. Population Forecast Use-Cases

In a use-case, a user is describing as an actor. An actor represents a user having a particular role when interacting with the system. A user is represented with a iconic stick man being an actor since he represents the source of stimulus to the system when interacting with the system. The use-case is shown as an ellipse, briefly describing the task. Where an actor participates in a use-case, then the relationship is shown as an interaction line between the two.

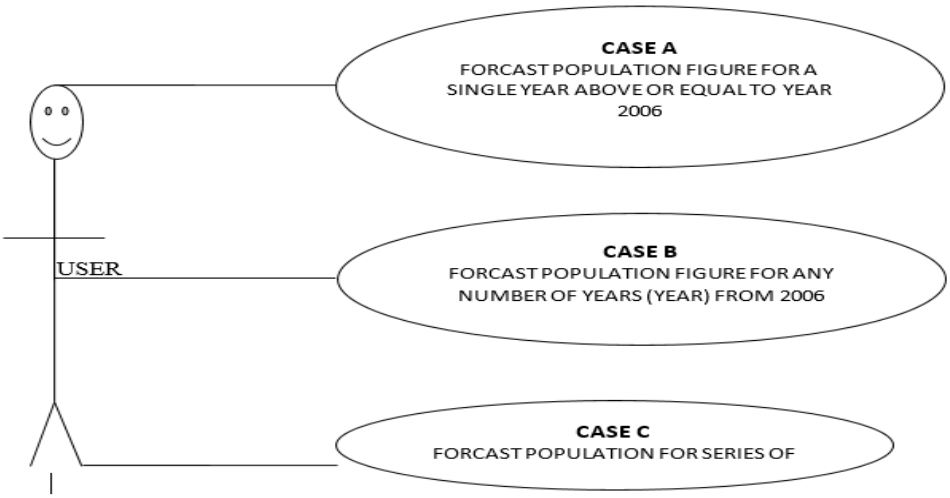

Figure 2: User Case

Case A helps to achieve the design of allowing the user to specify a single year that is equal to or greater than 2006 to view the population forecasted figure for that single selected year.

Case B helps to achieve the design of allowing the user to specify any number of years that is greater than zero(0) that will be added to 2006 i.e. 10 years specified refer to 2016

Case C helps to achieve the design of allowing the user to be specifying series of years like 10,20,30 years e.t.c.

9. System Implementation

This entails of the realization of the business logic, constraints, exceptions, and structure of the new system to be built or analyzed using a suitable programming tools that will aid converting the human ideas into machine acceptable form. This is where the programming language of choice is employed; in this case JAVA programming language was used and to my opinion is a good choice because of advantages it exhibited over other object oriented languages in its league. In a typical object-oriented system most objects do not exist as independent entities. In order that the overall system functionality is achieved, objects enter into architectural relationships, i.e. association or aggregation. This is a consequence of the fact that a well-designed object should be highly cohesive, i.e. it should undertake a small number of relatively simple, closely focused tasks. To be useful in a specific application it needs to be connected (coupled) with others to form a network of co-operating objects. On startup, the Fore. Class which is the parent and main class initializes every component in its constructor method Fore(), so that the GUI component can be interacted with as intended and ready to be put to use. The initialization follows a chronological order as specified in the main class constructor, that is why one GUI is created and initialized properly before it gets to the turn of another GUI component, and so it continue in that fashion until it gets to the last GUI component. The figure overleaf show how the Fore class initializes its component in order in the initialization sequential diagram.

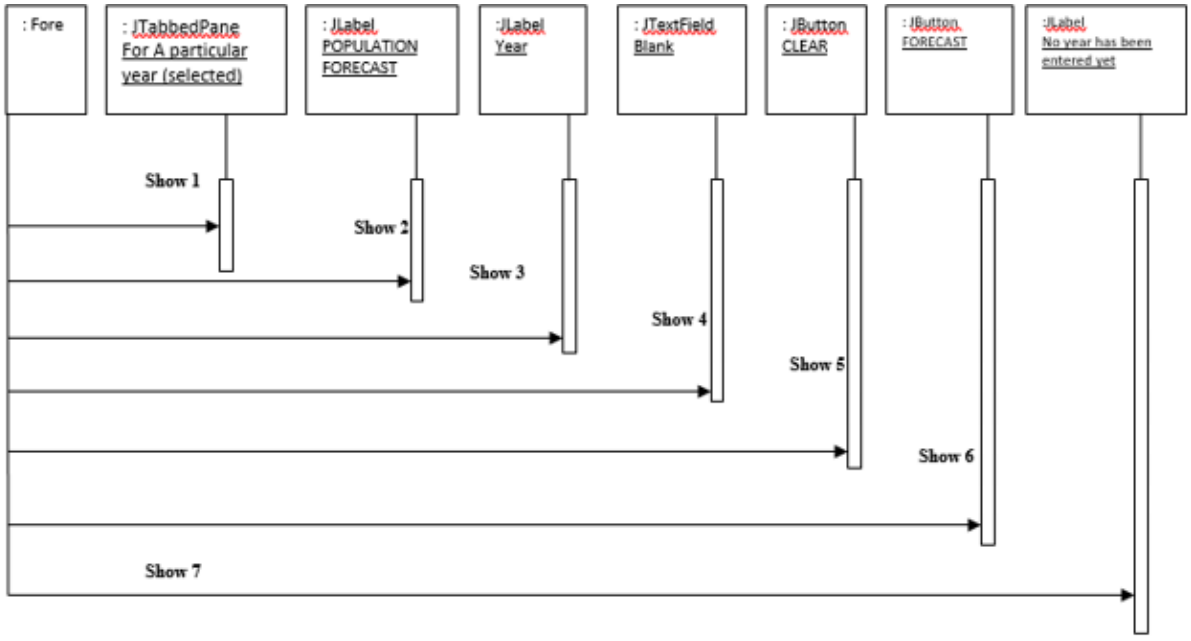

Figure 3: UML Sequence Diagram for Initialization

Note: Label on GUI component is use to identify a GUI component depending on the state of the parent class Fore class

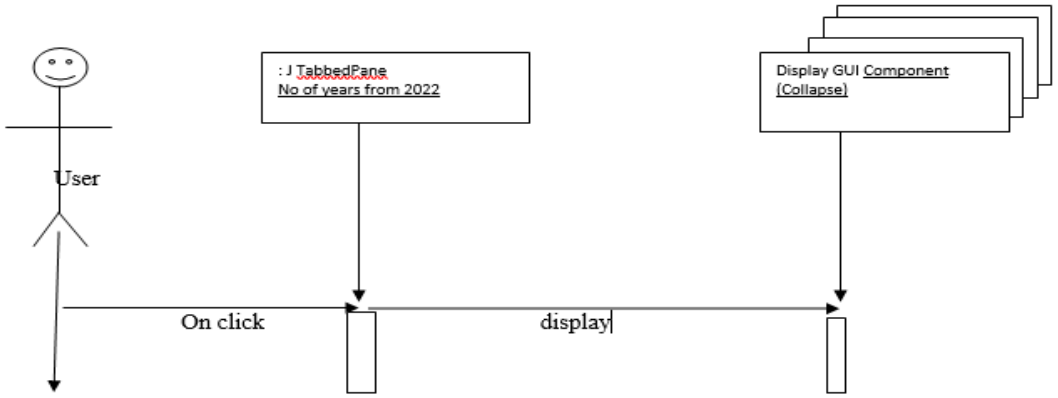

Figure 4: Sequence Diagram Realizations for Case C

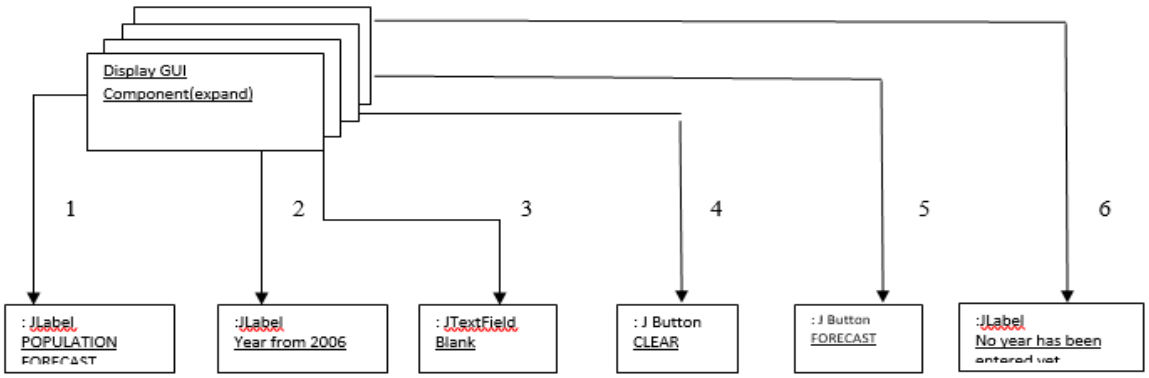

Figure 5: Sequence Diagram Realizations for Case B

Note: Label on GUI component is use to identify a GUI component depending on the state of the parent class Fore class

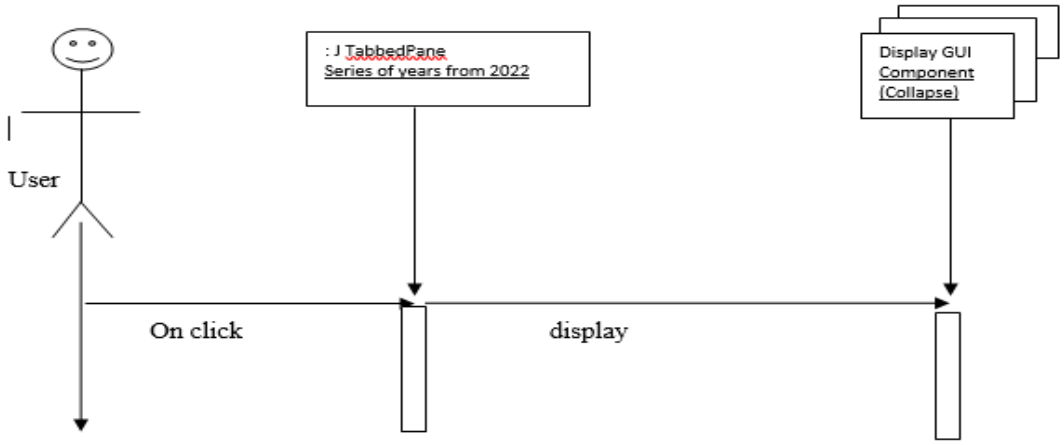

Figure 7: Sequence Diagram Realizations for Case C

10. Launching the Software

At the successful booting of the computer system, the command line (DOS) is not launched yet, click on all programs and search for the command line environment, click on the command menu to launch the command environment screen to issue the command that will launch the forecast application.

Change the prompt to point at the directory containing the java development tool use in launching and executing the application.

C:\>cd “Program Files\java\jdk1.6.0_11\bin”<Enter>;

The prompt then changes to

C:\Program Files\java\jdk1.6.0_11\bin>

Then type javac Fore.java to compile the source file

C:\Program Files\java\jdk1.6.0_11\bin>javac Fore.java

If no error the prompt returns with no error message, then type java to execute the java bytecode, like below;

C:\Program Files\java\jdk1.6.0_11\bin>java Fore

After this entry the application window is launch, then the necessary task can be executed by clicking the right tab and filling the text fields correctly.

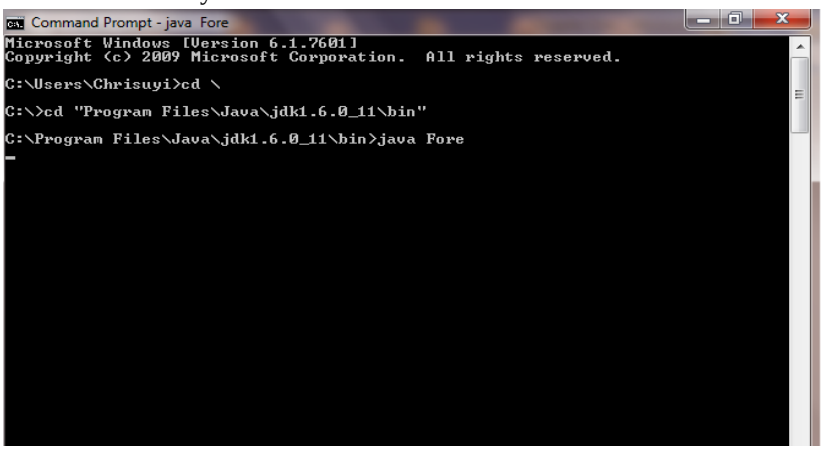

Figure 8: Screen Shot, the command environment from where the application is launch from

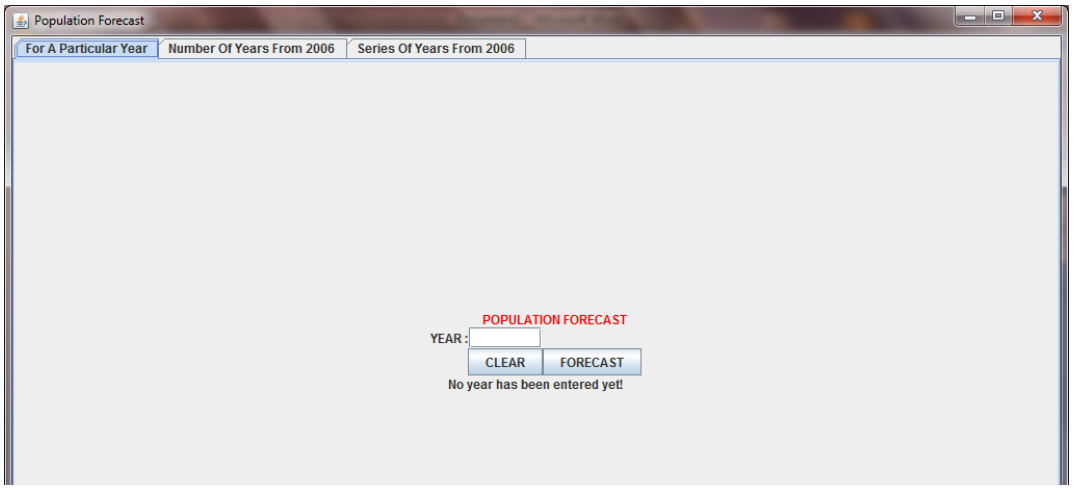

Figure 9: Screen Shot; Start up screen when "For A Particular year" tab is selected

Figure 10: Screen Shot 10; When "Number of Years from 2006" tab is selected

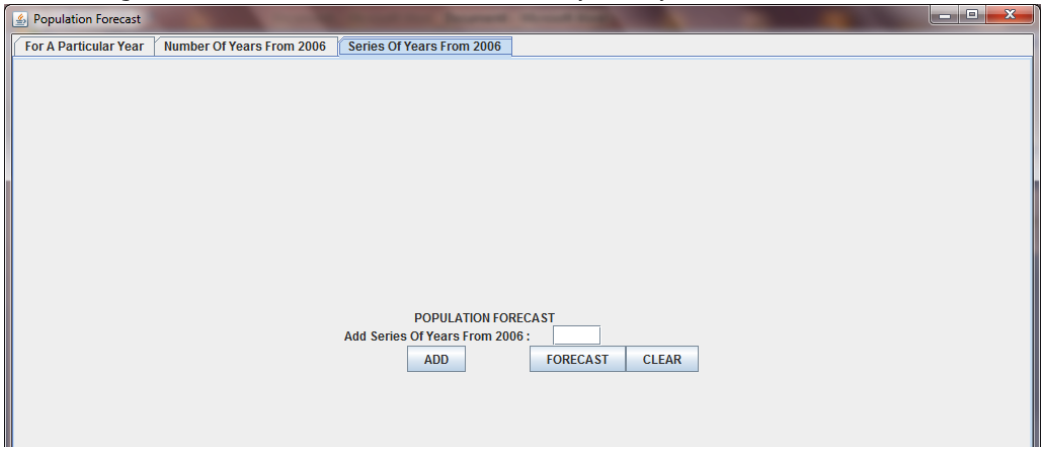

Figure 11: Screen shot when "Series of Years from 2006" tab is selected

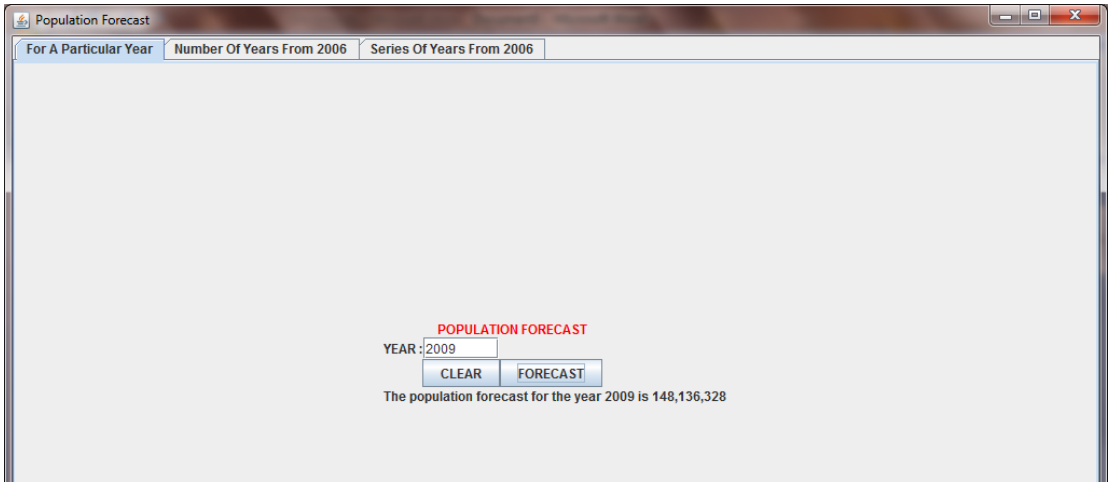

Figure 12: screen shot when "For A Particular Year" tab is selected and year 2009 is entered in the text field, and a population forecast figure of 148,136,328 was reached

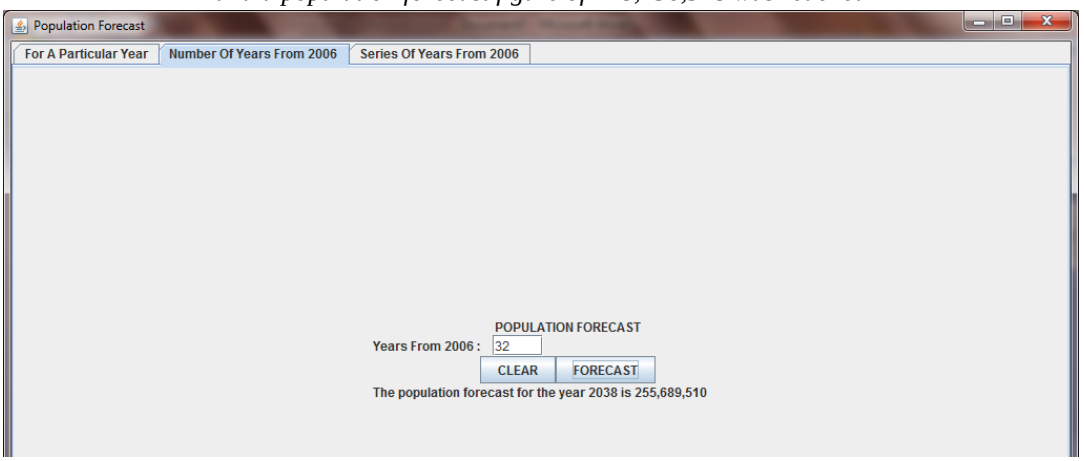

Figure 13: Screen shot when the "Number Of Years From 2006" tab is selected and 32 years from 2006 was entered, hence forecast is now for 2038 and population is 255,689,510

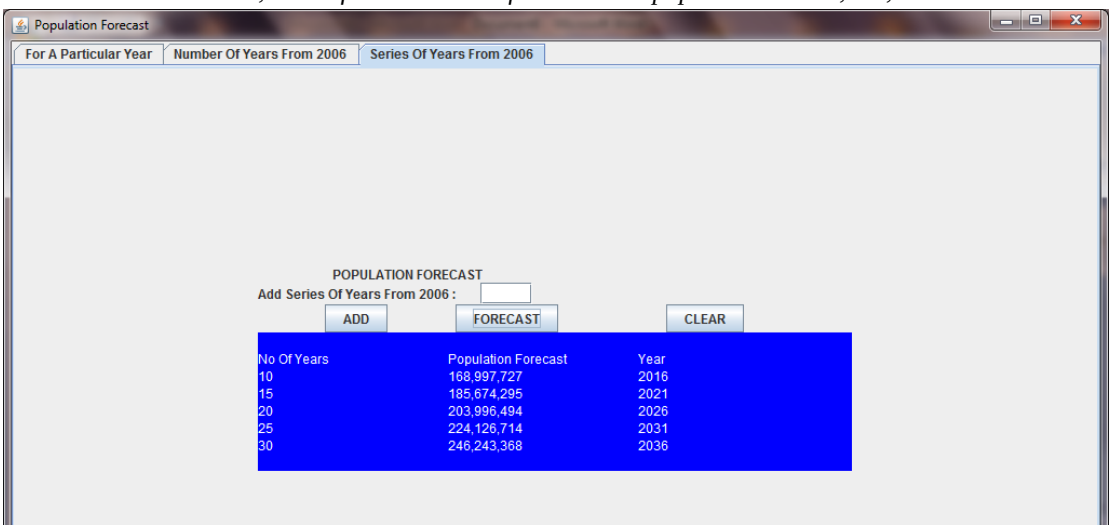

Figure 14: Screen shot when "Series Of Years From 2006" tab is selected. In this sample run the number of years that makes the series list includes the years 10,15,20,25 and 30.

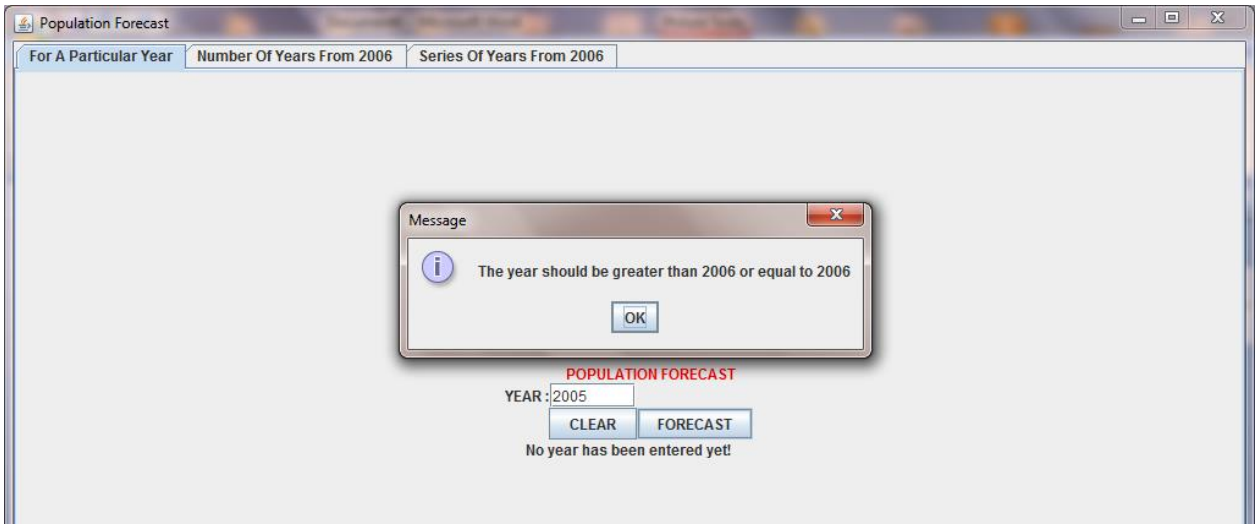

Figure 15: Screen shot when a year less than 2006 is entered in this case is 2005 that is entered in the text field. The dialog prompts the user that the year entered is invalid

11. Conclusion

Population forecast will continue to be an important tool for policymakers and planners, who need to know how many children need to be immunized or educated, how many people need food or employment and so on. Yet population forecasts are also necessary to provide some sense of the population-related challenges that lie ahead. It would help planner in setting out realistic targets. Nigerian's population trends have challenged the ability of the government and the land to provide sufficient basic amenities. The ongoing population change has affected prospects for sustainable socioeconomic and environmental development. Forecasts of population size and age structure are based on assumptions about fertility, mortality, and migration. Hence the main source of uncertainty of population forecasts is uncertainty about the future development of fertility, mortality, and migration (assuming there are accurate observations of the present size and structure the future is uncertain because the future development of fertility, mortality, and migration may be different from developments in the past or different in another way than expected. According to the results of our forecasting, the future educational composition of the Population will increase considerably in the middle school level over the next decades. This will be a significant benefit to sustainable population, socioeconomic, and environmental development. The changing of the educational composition of the population will coincide with the changing of the economic structure, with a slow Reduction in agriculture and a steady increase in the service sector. In this sense, the Combination of education and population projections significantly contributes to understanding sustainable development options for Nigerians.

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