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Smart-Intelligent System Framework Designing for Self-Tutoring In Robotic Programming for Children

Ibuomo R. Tebepah[1] and **Efiyeseimokumo S. Ikeremo**[2]

Department of Computer Science, University of Africa, Bayelsa, Nigeria

[1,2] E-mail address: tebepahirt@gmail.com , samplefiy@gmail.com

ABSTRACT

Though the main objective of designing a smart-intelligent system is for children to develop independent study habit with less supervision from teachers, parents, and guidance, it can also serve as a teaching tool or aid for teachers and children minders within the class and virtual classroom. The framework was derived after a critical review of related literature, the usage of mobile devices amongst children (analysing their user experience), and existing application and IDEs for children. The designed framework comprises components such as user analysis, log files, database, initial user data input, provisioning and hybrid machine learning algorithms that facilitates the smartness and intelligence of the system. Though the framework was not demonstrated in this paper, it however, it can be implemented using any programming language supporting object oriented approach. For procedural programming languages, minor adjustment on the process flow will enable it to work effectively.

Keywords**:** Robotic Programming, robot operating system, framework, tekkotsu

1. INTRODUCTION

One of the frequently asked questions when advocating for people to learn programming is ‘what is the minimum age a child could reach before they can be taught programming’? The answer to that question is, when a child can identify objects and different colours, such a child is ready to learn programming regardless of the age. This view is held due to the high rate of

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mobile device dependency of children. The use of mobile device as a means of controlling children restiveness is on the rise, and so are the applications (games) for children.

Modern teaching-learning is becoming more flexible, interactive and adaptive [1] with the application of technology and utilization of smart mobile devices to access digital resources.

This has made learning activities seamless, available and personalized (adaptive) to the learner. Smart learning is used to describe learning that occurs through the medium of digital devices, application which is believed to increase retention. It is learning in the digital age. However, different authors and researchers have different understanding or usage of the concept. SMART could be taken as an acronym - Self-directed, Motivated, Adaptive, Resource-enriched, Technology-embedded education [2]. It is a well thought out concept that encapsulates the entirety of learning – objectives, resources, content, context, and presentation. Thus, smart solutions are bundles of different apps which each app performing a specific task or rather help a learner in achieving a specific goal or performing a learning activity.

There are other simplified description as published in the work of [3] defining it as a technology-supported environment for learning. The technology enhanced learning (TEL) model of [4] is similar to [3] view. By these, it can be generalized that the use of technology makes the learning process smart, if all other factors are not put into consideration or held constant. An aspect of smart learning that of interest to technologist is the level of intelligence of the system, the ability of the system to automatically make decisions and adapt itself to different learning requirement and specifications without any direct input from the user. That means the system is able to support and analyse exiting data and blend seamlessly to the intelligent learning space [5], with no reference (independent) to the users. Speaking of technology applications especially in relation to smart and intelligent system, artificial intelligence serves as the vehicle through which it is achieved. Smart-intelligent systems are powered by AI in the form of machine learning and deep learning algorithms with the capability of processing both structured and unstructured data. The research on applied an AI enabled smart system called integrated multimedia teaching model (IMTM) [6], is a comprehensive smart educational resource that enhances users' capacity in listening and oral expression. The infiltration of artificial intelligence in our world has brought to clarity many supposedly challenges [7], with the integration and extensive applications of new generation computing technologies such as deep learning, cloud computing, big data, there has been a great leap forward in every sector including education. Education being the bedrock or foundation of technology (founded on research) has been greatly influenced, and it is almost becoming impossible to conduct teaching-learning without the use of some sort of technology. The application of machine learning in solving human and machine complex problems, and its success can be attributed to the support of computing capabilities and the technology that backs such processes. Where as, learners could easily adapt or transfer knowledge gained in using mobile devices for conventional purpose, teachers sometimes have the challenge of knowledge transfer. This can be attributed to several factors such as variation of time spent on surfing the internet, interest in social media activities, level of technology savviness, and interest. This does not consequentially mean that young mobile users completely adapt and accept smart-intelligent learning systems. There are intrinsic and extrinsic factors presuppose acceptance or rejections. In understanding learners' level of participation of intelligent teaching, the empirical study of [8] considers AI usefulness, interactive reward, satisfactory support and enjoyment for dynamic activities within the system. Notably of the system is the need for smart resource allocation which enables control and effective management of resources. However, it was also observed that despite the high possibility of knowledge transfer of amongst learners when giving the opportunity to use teaching-learning application, learners are reluctant. The reasons could be generalized as interest and content presentation. This does not imply by any means that smart-intelligent system should not be used, but rather, better adaptive techniques and learning pedigree should be considered when designing such applications. Also, the age grade of the supposed learners is an important attribute that should be captured within the design. The instance of [9] used virtual characters as intelligent tutors in teaching simple geometry to children. It is an embedded system that uses the combination of augmented reality and mobility, which created a pleasurable experience in the children influencing them to memorizing processes and figures subconsciously. The work of [10] explained and demonstrated learning activities using unmanned aerial vehicle (UAV), involving collection of data, learning how to fly working in the field with UAV and programming. The main advantage of using UAV in learning according to their work is accessing data from inaccessible or dangerous locations, collecting and delivering temporal and spatial resolution information quickly.

The experimental work of [11] with students studying architecture, having different perceptions and experiences in using remote learning systems. Their perceptions were based on the environment (platform) that is being used especially for programmes and courses that traditionally designed for a face-to-face studio method of teaching-learning process. The suggestions from [12] work in creating a smart classroom using technology was aimed at replicating the familiar traditional classroom setting that makes learning process easier for both students and teachers. The technology powered classroom should enable the presentation of various teaching materials and relevance, necessary for personalized learning group learners, mobile and virtual learning related activities. The smart-intelligence should be able to provide adjustment for the individual students through the implementation of specific algorithms in ML that is able to analyse the context of learning, its environment and individual activities and adopt to the scenario. In all, the aim of structured learning is peculiar and usually tailored towards to achieving the ideology of the locality. This ideology do influences and is reflected in the manner in which technology is or can be used in education. Its success or failure is predetermined by the extent to which the authorities will want technology to be deployed in education through the provision of the necessary support in terms of funding.

Relevance of RP

The convergence of robotics and other fields has proven beneficial and aided in the rapid development of the fields involved. Developmental robotics [13] is coined to connote the use of robotics in proffering solutions to different fields such that it aids the development of the field. Consequently, robotic projects are problem solving oriented whether it is in game format or conventional machine representation, it is expected that the robot is offering help or solving a human problem. Thus we have seen high percentage of robot usage in the creation of adaptive manufacturing [14] for reconfiguring manufacturing process that forms an integral and flexible system, thereby making its complex operations seem rudimentary, and taking care of possible discrepancy usually caused by manual operations.

Considering the globalisation of activities, the quest of new discovery and conquering, researches in space and its galaxies has taking a newer and more innovative dimensions with the use of robotics [15] in its exploration missions for scientific observations and human activities in deep space. The implication of this is, technology can be used to construct, repair, and maintain communication in space orbit. While robots are used to facilitate activities in the different industries such as the manufacturing, the knowledge gained in learning or studying robotic programming is transferable as suggested in [16, 17] in the area of computational thinking. As such learning centres and educational authorities are making frantic efforts to encourage the inclusion of robotic programming curriculum at an early stage in formal education. In addition it said that robotics programs are increasingly being used to meet goals in science based subjects [18] through children collaboration. The opportunities created in teaching robotics programming as also created opportunities in other known fields [19] involving fabrications, 3D printing and modelling of objects. Thus, introducing robot programming courses must evolve to reflect the realities of its complexities and intricate composition [20]. While it should be a gradual process with precise and specific objectives at every stage, its introduction at the foundational level of a child's education is eminent and relevant for achieving world relevance.

Robotics Framework

While the designing of robot is a very complex series of activities, yet there are both OpenSource and proprietary frameworks, and sometimes source available for developers to use and build-on. An example of an OpenSource robotic framework is the TEKKOTSU [21] application framework that is based on Object Oriented using the C++ extension templates. The framework is organised as a collection of behaviours and motions, with the command classes.

The key elements or components of the framework are; main process, world state, motion manager, motion process, sound process, sound manager, motion command and TinyTTPD. The general operational process is represented in the pre-emptive process, shared memory region and unshared global variables. Robot Operating System (ROS) [22], still an OpenSource framework that is regarded as an operating system for robotic app. The framework defines the components, interfaces and tools for building advanced robots for various industries such as; agriculture, manufacturing, construction, factory logistics, planetary exploration, food processing and many more. It provides the actuators, sensors, the software and the control systems through which robots are built for specific use [23]. Despite the elaborate and sophisticated provision of tools within the above frameworks, it is meant for students with previous robotic programming experience. As already stated, the building of robots is a complex process, and requires a well-grounded basic knowledge or foundation for a starter. Thus the proposed framework design is to create an avenue for systematic learning content provision, and a practice platform for laboratory exercises that will be provided in the course of learning.

2. MATERIALS AND METHOD

The study reports on the process of designing a framework for a smart-intelligent system using the unified modelling language tools. It identified the components that comprises the system as; classes, interfaces, virtual tutor, MLAs, lesson content, content presentation, log analysis, user dashboard, and data store. Since it is a smart-intelligent framework, there were specific consideration as each component was designed to suit children learning on their own with less supervision. These considerations include; concentration span, rate of assimilation of new conceptions, difficulty level of content, presentation perception (look-and-feel of the environment/platform), and subject matter. In the case of the age grade factor consideration, the random sampling observation (RSO) technique was used. This technique randomly samples the sample set (35), and were observed while they used digital devices. Ordered questions were asked as each child used it for various activities. In situations where the respondent is more than one, there was frequent interaction between and amongst them, with very similar responses. The collated responses of the respondents formed the attributes/variables that were taken to cognizance in the design. This process justified and authenticated the variables as determinants.

At the end of each RSO, the results were weighted along the main learning pedagogy; which are cognitive, psycho-motor and affective. The weighting entailed how each identified attribute strengthens the learning domains.

3. RESULTS

The results are showing in diagram form as seen in Figure 1, Figure 2, Figure 3, and Figure 4

Framework Design

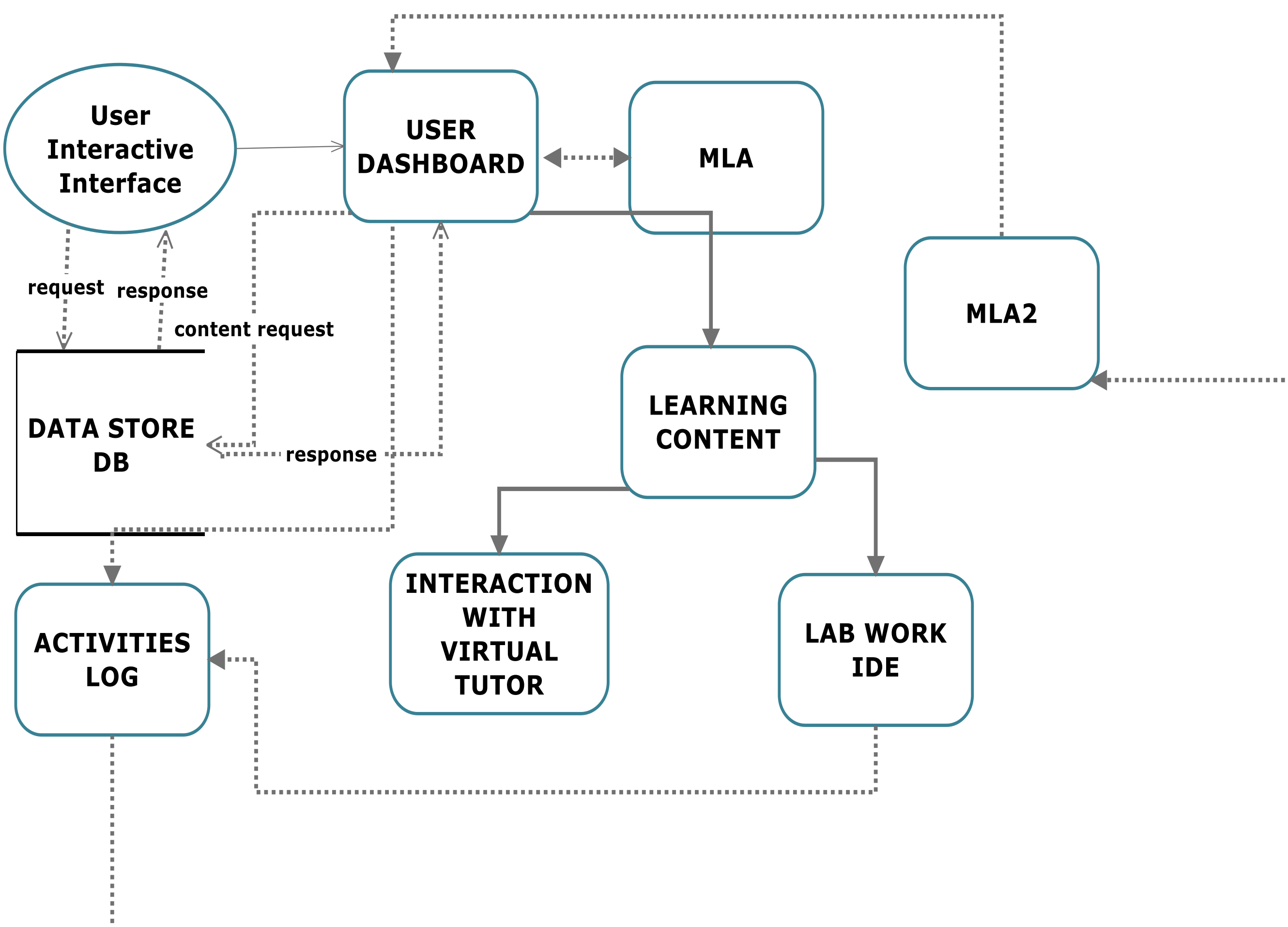

Figure 1. Smart-intelligent architecture

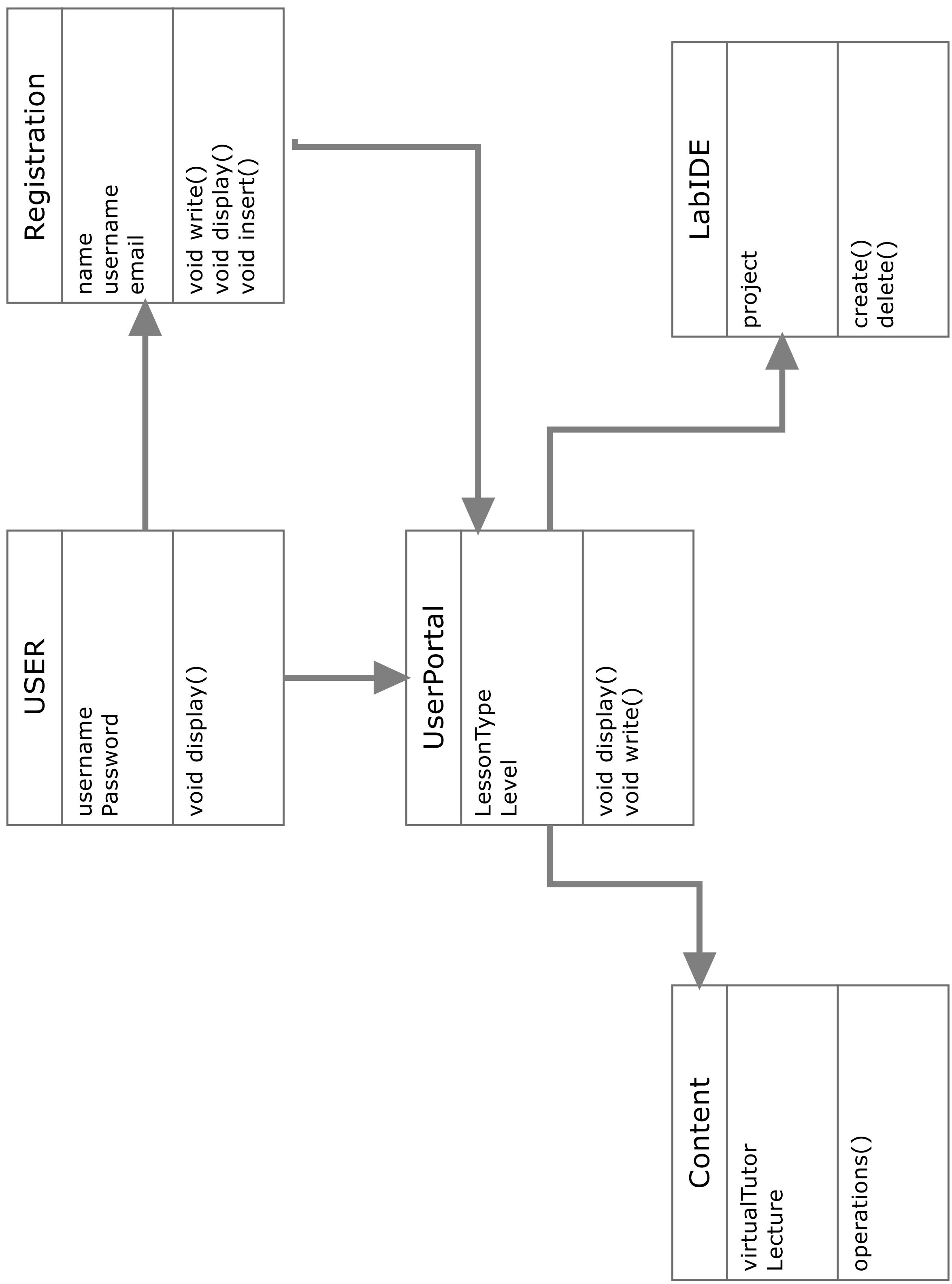

Figure 2. Basic class structure

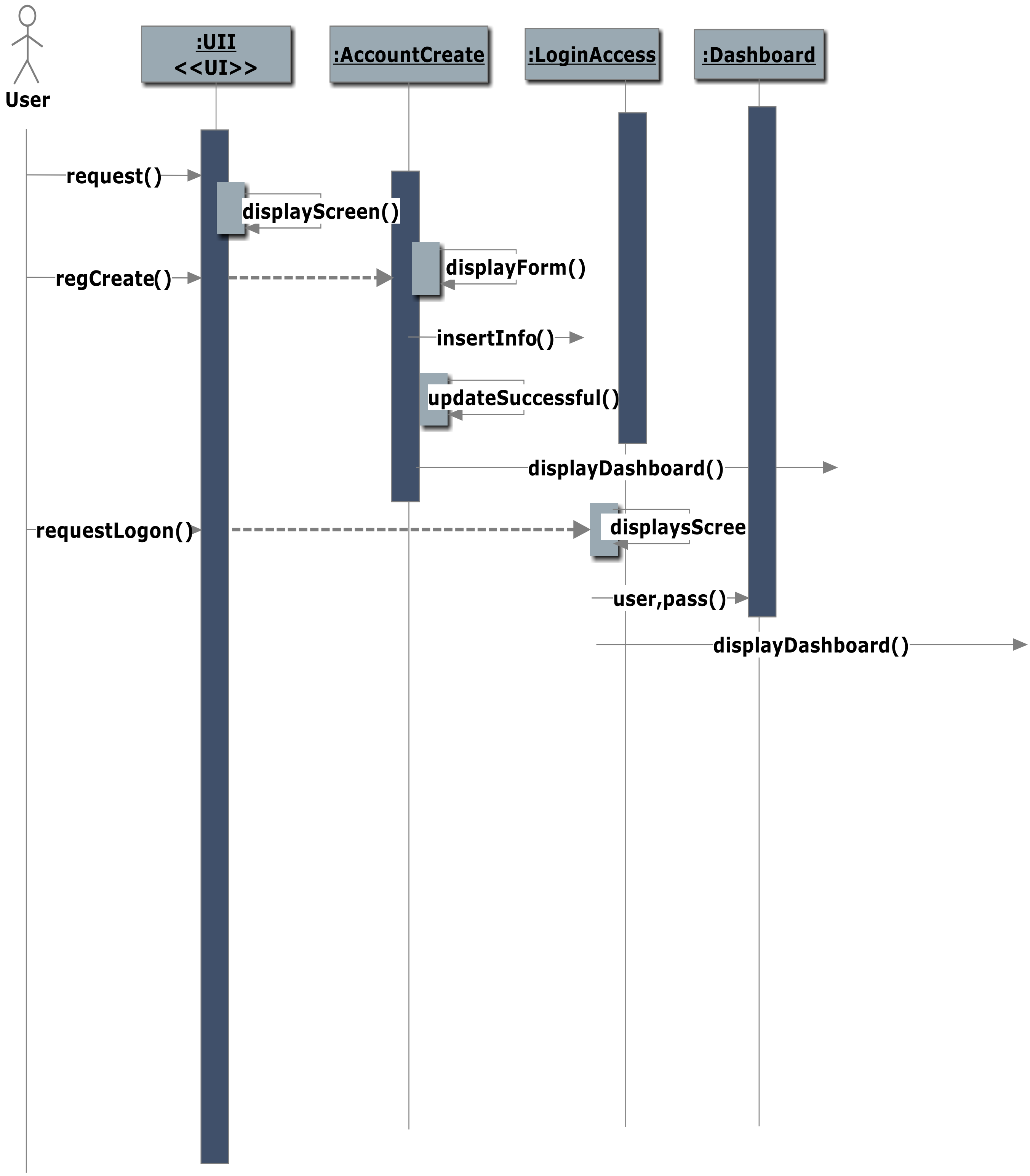

Figure 3. The System Sequence Diagram

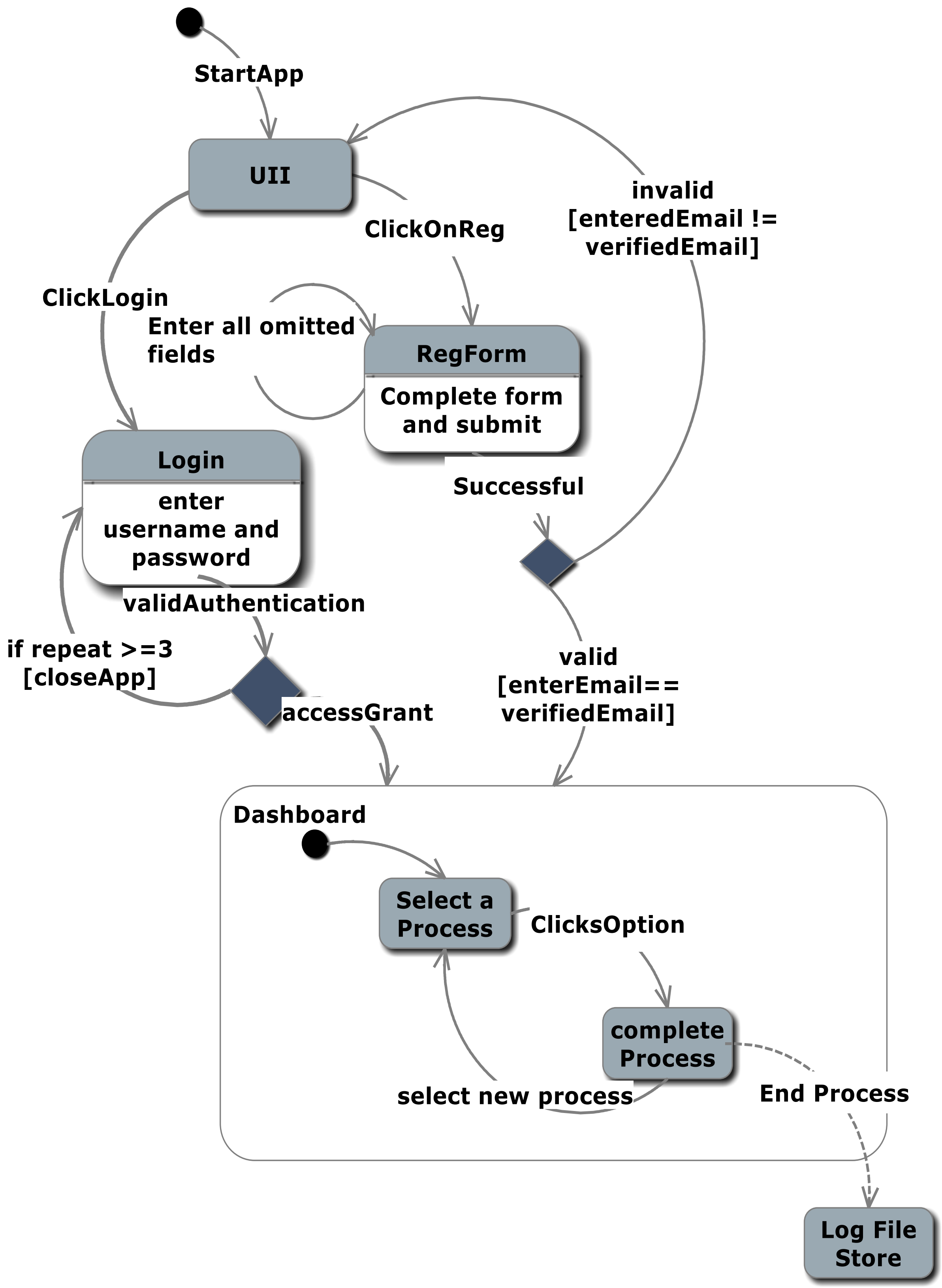

Figure 4. System Process State Diagram

4. DISCUSSION

User Interactive Interface (UII): The UII component is the first displayed page at the start of the application and it contains sub-components such as the welcome, registration and login. It also includes description of the app, with its name on the page. The page brings up a pop-up chatbot when it notices inactivity after 59 seconds of app initiation. As a user hovers on each subcomponent, a brief description of the component is displayed that serves as a guide on what the component is used for. The registration subcomponent as the name implies is to enable prospective or intending user of the app to create an account that will be provisioned through authentication via email. The registration is a necessary requirement, without it, a user will not gain access. The content of the registration subcomponent is displayed in form format requesting for basic user details. Login subcomponent contains label, textFields for the username and password with a submit button. With the label, the user knows where to input their username and password. The submit button is created to read and transfer text inputted in the textFields to the appropriate and corresponding data fields in a specific table within a database.

User Dashboard (UD): The user dashboard is activated when a user successfully logs onto the system. It is the user profile page. The dashboard is the main working component of the user as it contains several subcomponents; username, logout button, update profile, learning content, level, and feedback. Each of these is taking to logical conclusion, thereby completing a specific task. For instance, the learning content though a subcomponent within the dashboard, yet is a major component as it has several elements embedded in it.

Machine Learning Algorithm (MLAs): This is a logical component as it exists virtually within the dashboard. That means that its effect is seen or determine when the dashboard is viewed, and it makes learner centric suggestions. MLAs are presented in form of mathematical model, giving the designers and the programmers to create appropriate variable for each symbol for computation.

Data Store (DS): Data store houses all of the data within the app. The stored data includes; user details and learning content that are presented in different format and medium. DS contains both structured and unstructured data. Registration details and learning content are presented in structured manner, while the log files (activities log) are unstructured.

Activities Log (AL) otherwise known as log files is an unstructured data that captures user activities. It is the totality of user interaction with the app, which is used to postulate UX. These are used consequently to determine or proposed possible activities for the user. For instance, if in the activities log, it has been determined that a user has completed the basic lesson of a particular learning content, when next they login, the system will suggest a different learning content or a high level of the previously completed lesson. If it was not completed, they system also suggest to the user to complete the outstanding lesson before proceeding to the next level.

Learning Content (LC) component is made up of the learning material/resources that is presented in different format (multimedia and text). Content is planned, prepared following the teaching-learning objectives by trained specialist on the subject matter and uploaded. Uploaded materials can be downloaded or viewed only. It is arranged according to the difficulty level – basic, intermediate and advance. It is expected that a learner starts from the basic, however, limit is not placed as a learner can choose to start from any level. Content is further broken down into various lessons. The number of lessons for a specific topic depends on how broad (coverage) the topic is. It is expected that every lesson is presented starting from the rudimentary to the sophisticated, and it should be a buildup of previous topics. Thus, lessons are arranged in a systematic and sequential order, making it easy for learners to follow.

Interaction with virtual tutor has two possibilities; real time teacher which is possible through a request form, and a robot virtual tutor. Learners are at liberty to make their choice. The expected virtual classroom is to take the pattern or setting of the traditional classroom.

Lab Work IDE (LWI) component was included present an all-in-one app; for learning and practice environment. Each lesson is required to be accompanied by a laboratory work. The essence is to drive in the principles and skill learnt in the course of taking the lesson. Children of the age in view can easily get distracted and bored when they are a passive.

Classes

The class structure is the transposition of the various components into programmable units. Each component is represented in a single class with inner classes and extended classes. This makes it possible for abstraction and encapsulation of events and actions that protects the user. Figure 2 is a basic representation of the app. The name of the class is displayed at the top, followed by the attributes (variable names and types), and the method (action).

Each class though distinct, yet interfaces with other classes seamlessly in a sequential order, giving the app a modularized and subset outlook. The implication is that the component can function in a sectional way independent of other component, but yet can be conjugated to form a singular entity.

System Sequence

The system sequence is a representation of functional modalities. It shows how activities are expected to be done. In figure 3, the rectangle boxes represent the different classes/interfaces on which the activities are being performed. It also shows the end of the activity. Thus, each task or activity is carried out within a class.

Process State

The Process State (PS) represent the transaction state of the system. That is how processes are initiated, handled and ended. It shows the mechanisms of error handling or correction, gradual or quantitative easing of processes if there is an abrupt interruption.

5. CONCLUSION

This study reported on the designing of a smart-intelligent system framework that would enable children to develop independent learning skill using robotic programming as the subject matter (learning content). The developed framework can be implemented on different subject content and multiple contents, for different age grades. It is adaptable, flexible, and robust enough to accommodate mobility, web enabled, and standalone depending on the implementation. The designed framework allows for IDE integration, making it easy for practical or laboratory exercises to be done with ease without necessarily depending on a third-party IDE. It is usable by both teachers and learners, and can be deployed at home and places of learning when implemented.

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