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Research Article

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A Smart Home Model for Independent Daily Living Activities

Imumesen O. Solomon[1]*, Nuka D. Nwiabu[2], Bennett E.O.[3]

*[1]Department of Computer Science, Rivers State University, Nigeria
[2]Department of Computer Science, Rivers State University, Nigeria
[3]Department of Computer Science, Rivers State University, Nigeria

Abstract While a significant amount of research has been carried out on producing smart home technology for independent daily living, less attention has been paid to building a model that can predict and monitor the daily living activities of the house occupants for safety. This research is aimed at developing a model for a Smart Home that can enable its occupants engage in Independent daily living activities. This model can be used by a programmer to build a full system with users' interface, as well as an app that can be installed on a mobile phone to monitor various activities. Machine learning was utilized in the system for the process of learning the activities of the occupant over time and operating within the house without any assistance. This will enable these individuals live independently with minimal attention from their caregivers. For this work a published ambient dataset generated from residents going about their daily living activities with different sensor installed to monitor their activities was used. An activity prediction approach using Deep Neural Network (DNN) was used to predict the various activities performed by the occupant using designated parameters. The result obtained from the model on the various activities carried out by the occupants showed that some of the activities were wrongly predicted while some where correctly predicted. Evaluation was carried out by comparing the DNN model results with experimental dataset and the result shows 70% accuracy.

Keywords Smart Home, Rapid Application Development, Artificial Intelligence, Deep Neural Network

Introduction

A Smart home is a technologically enabled and computer connected home that is able to control and monitor its home appliances and make decisions as to their use on its own. The purpose of a smart home is to increase the living comfort of the resident; it can also control and monitor the activities in the building with the help of a smartphone. These modern systems include switches, sensors and actuators that communicate with the central axis known as the gateway [14]. A Gateway is a control system that has a user interface which interacts with a tablet, mobile phone or computer with the help of the Internet of Things (IoT) [4],[11]. Smart homes are an amalgamation of technology and services through which home networking ensures a certain quality of lifestyle for the humans living in it. Throughout the house, there are different appliances, sensors and a monitoring system with a centralized hub which, control and facilitate automated environment for user's interaction as mentioned earlier [13].

The integration of intelligent equipment in the home is made possible through the concept of internet of things (IoT). Internet of Things (IoT) has been regarded as one of the disruptive technologies of this century, it has been in the spotlight for the past decade, and has helped in the creation of new business models, products and services. Internet of Things (IoT) allows people and things to be connected at anytime, anywhere, with anything and anyone using any network and services [5],[11]. The Internet of Things (IoT) has changed human life by providing connectivity to everyone regardless of the time and place [4],[16].

Machine learning is an application of Artificial Intelligence (AI) that provides systems with the ability to automatically learn and improve from experience without being explicitly programmed [9]. It focuses on the development of computer programs that can access data and use it to learn for themselves. Many organizations are investing in neural networks to solve problems in various fields, in this regard, Artificial Neural Networks (ANNs) are found to be a unique and useful model applied to problem-solving. ANNs are a machine learning information management model based on the biological nervous system functions of the human brain [15],[3]. To expatiate further, an Artificial Neural Network (ANN) is a machine that is produced to function the same way the human brain performs a given task of interest. For instance, "the human brain is big and highly efficient. It is also known that human brain is like an information-processing machine that has a variety of complex signal computing operations" which can be easily coordinated to perform a task, the main element of the brain is the unique design of the information processing capability which constitutes many complexes interconnected "neurons" in the form of elements working together to solve specific problems on daily basis. A typical example of a neural network function is the human brain that is connected to send and receive signals for human action.

In the business setting, one of ANNs advantageous applications is that it can easily be used to make models and more accurate from complex natural systems with large inputs [6],[7].

In our research, the process of learning will start with observations in order to look for patterns that will make better decisions in the future, our aim is to allow the system to learn automatically without human intervention for the comfort of the people and by using a framework in making decisions such as Remember-Formulate-Predict, where the supervised model will first remember the dataset of the occupant and formulate a model or rule to identify the occupant and then make a prediction.

Materials and Method

- **Research Method:** The Qualitative research method was adopted because of its flexibility; it allows numbers of interaction between researchers and study participants. This method enabled the use of semistructured interviews composed by open-ended questions, for gathering individual answers of participants' experiences in a smart home, through which the challenges experienced and ways to overcome them were revealed.
- **System Design Method:** Rapid Application Development (RAD) methodology was utilized because it is a software design methodology that is designed to counter the rigidity of other traditional software development models. The RAD approach enabled a fast project turnaround time.

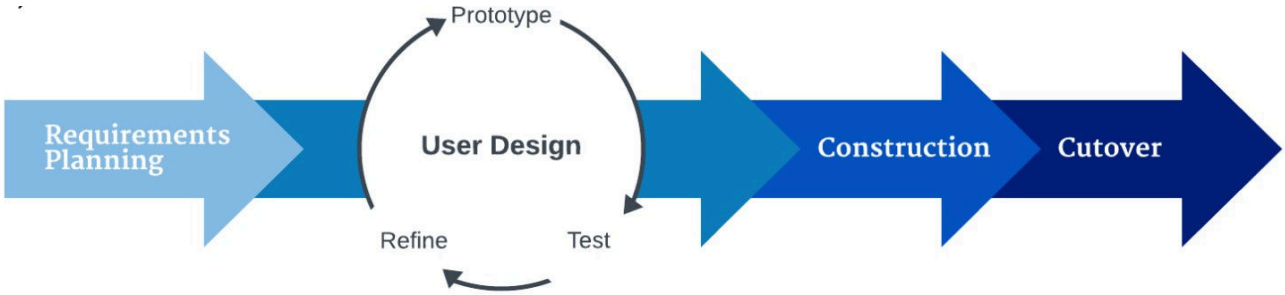

Figure 1: Rapid Application Developments (RAD)

- **System Architectural Design:** Deep Neural Network (DNN) model was used to split the dataset into training and testing data and further used to train the model to obtain the desired result. Training data are very large amounts of dataset that is used to teach the machine; over time this machine learns the various activities and uses 70% of the training data for prediction with the help of the algorithms which was used to extract the features that is relevant. A test dataset is a dataset that is independent of the training dataset, but follows the same probability distribution as the training

dataset uses 30% of the dataset as the testing data. The model was trained using testing dataset for results and predictions.

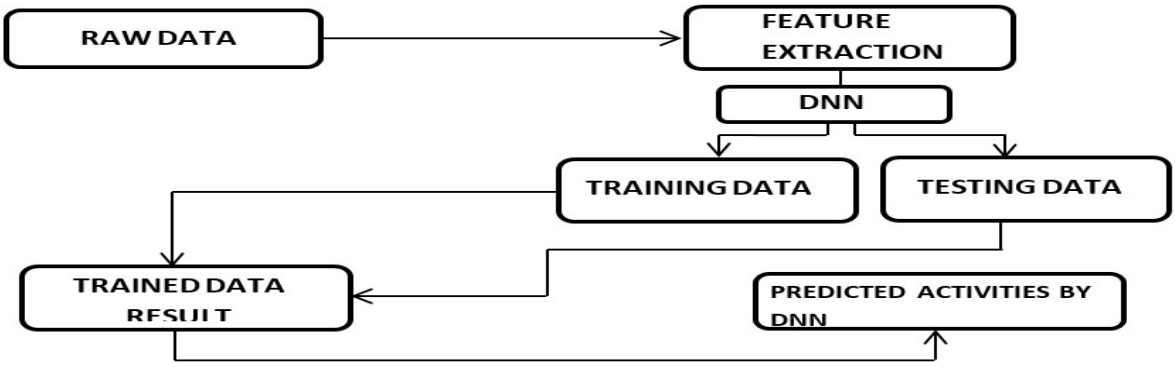

Figure 2: Deep Neural Network (DNN) Architectural Design

- **Multi-layer Perceptron (DNN Network Model):** Multi-layer perceptron (MLP) is a supplementary variation of feed forward neural network. It consists of three types of layers—the input layer, output layer and hidden layer, as shown below. The input layer receives the input signal to be processed. The required tasks such as prediction and classification are performed by the output layer. An arbitrary number of hidden layers that are placed in between the input and output layer are the true computational engine of the MLP. Similar to a feed forward network, in a MLP the data flows in the forward direction from input to output layer. The neurons in the MLP are trained with the back-propagation learning algorithm. MLPs are designed to approximate any continuous function and can solve problems which are not linearly separable. The major use cases of MLP are pattern classification, recognition, prediction and approximation.

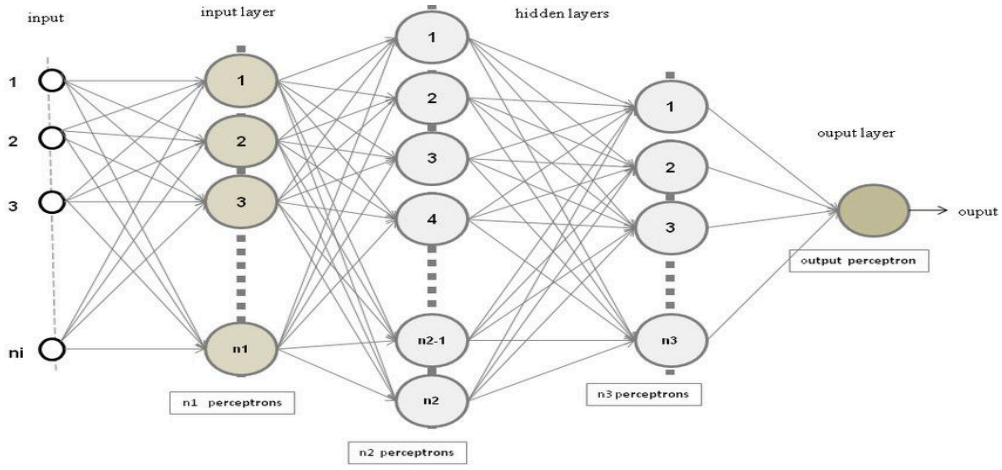

Figure 3: DNN Network Model

The above model used several input parameters such as lastSensorEventHour, lastSensorEventSeconds, lastSensorDayOfWeek, windowDuration, timeSinceLastSensorEvent etc. After inputting the parameters, the output activities came up based on the input given. The model produces only one output at a time(for example; Watch_TV).

Results & Discussion

Smart home model for Independent daily living activities was implemented using Python Programing Language. The system detected actions performed by the occupant with the help of sensors to monitor their daily living activities. It was also able to assist their daily routine by correctly predicting activities they would perform with about 70% accuracy.

Table 1: Predicted Result of Daily Living Activities

Test	Actual Activities	Predicted Activities
1	Watch_TV	(Other_Activity)
2	Entertain_Guests	(Personal_Hygiene)
3	Entertain_Guests	(Entertain_Guests)
4	Entertain_Guests	(Entertain_Guests)
5	Entertain_Guests	(Entertain_Guests)
6	Entertain_Guests	(Personal_Hygiene)
7	Entertain_Guests	(Entertain_Guests)
8	Entertain_Guests	(Other_Activity)
9	Entertain_Guests	(Entertain_Guests)
10	Sleep	(Sleep)
11	Personal_Hygiene	(Entertain_Guests)
12	Other_Activity	(Other_Activity)

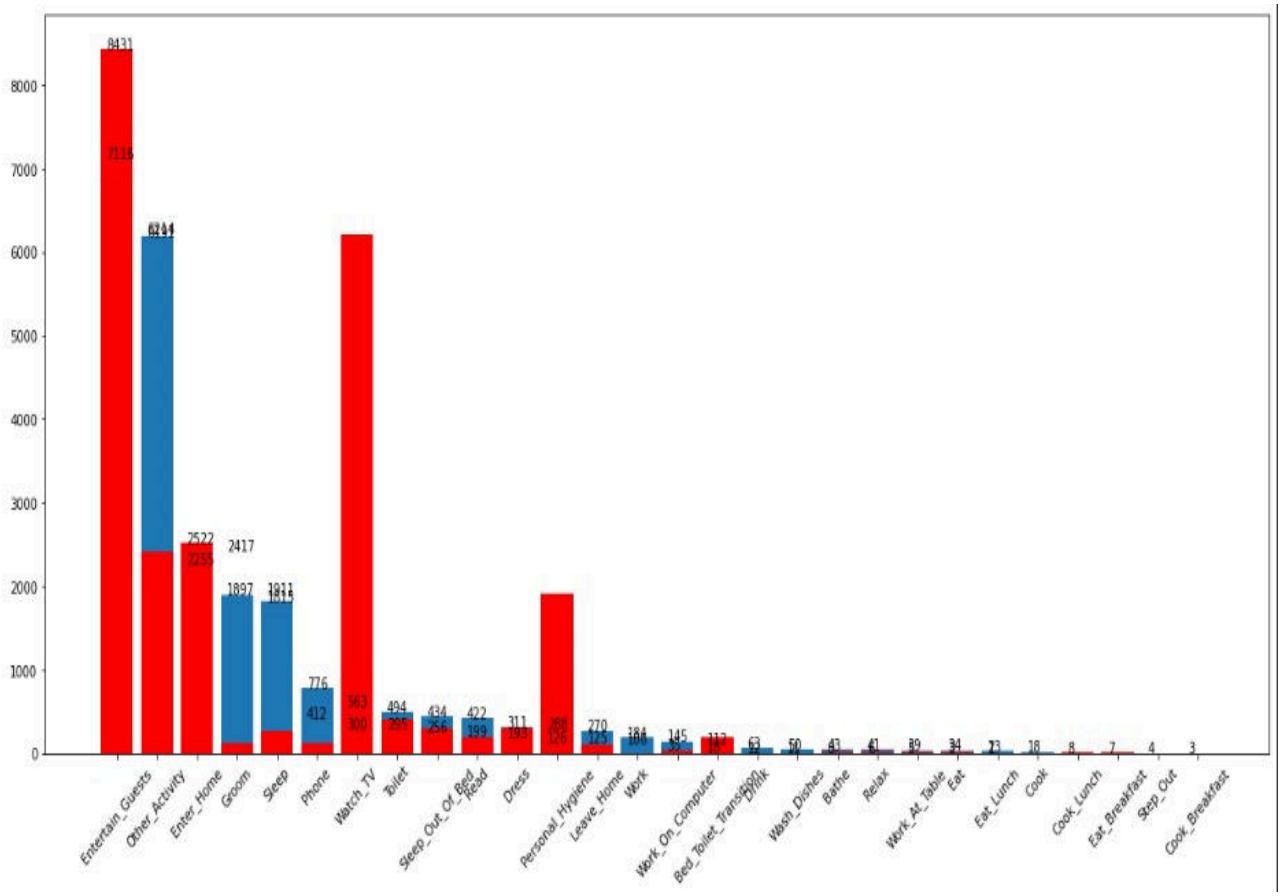

Figure 4: Comparation of Actual and Predicted Values

Conclusion

Smart home independent daily living is built to support physically challenged people, for example, the elderly or disabled, who can definitely benefit immensely from a home automation system that employs artificial intelligence. These systems offer those who are less mobile, or in delicate health the opportunity to be independent, rather than staying in an assisted living facility. The model has recorded good performances

which enable the prediction of daily living activities of the occupant. The model also creates an avenue for the caregivers to monitor the various tasks performed by their charges and predict if there is any abnormality taking place at home, for instance fall detection. The research work also shows that deep neural network (DNN) has shown a higher level of accuracy when trained with large data size, which enabled the development of a model that monitored the daily living activities of physically challenged people using sensor data. Also, with the help of Deep Neural Network more attributes can be added to the system when needed.

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