IoT for smart home system

Puji Catur Siswipraptini, Rosida Nur Aziza, Iriansyah Sangadji, Indrianto, Riki Ruli A. Siregar, Grace Sondakh
Department of Informatics, Institut Teknologi PLN, Indonesia

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ABSTRACT

This paper examines the integration of smart home and solar panel system that is controlled and monitored using IoT (internet of things). To enable the smart home system to monitor the activity within the house and act according to the current conditions, it is equipped with several sensors, actuators, and smart appliances. All of these devices have to be connected to a communication network, so they can communicate and provide services for the smart home's inhabitants. The smart home system was first introduced to provide comfort and convenience, but later it should also address many other things, e.g. the importance of the efficient use of energy or electricity and hybrid use of energy sources. A solar panel is added to the smart home prototype and its addition is studied. Adaptive linear neural network is implemented in the prototype as an algorithm for predicting decisions based on the current conditions. The construction of the proposed integrated system is carried out through several procedures, i.e. the implementation of the adaptive linear neural network (ADALINE) as the neural network method, the design of the prototype, and the testing process. This prototype integrates functionalities of several household appliances into one application controlled by an Android-based framework.

Corresponding Author:

Riki Ruli A. Siregar
Department of Informatics
Institut Teknologi PLN
Jl. Lingkar Luar Barat Duri Kosambi Jakarta Barat, Indonesia
Email: riki.ruli@itpln.ac.id

1. INTRODUCTION

A smart home is one of the computing and information technology applications that connects several smart objects and household devices or appliances capable of sending information and provides connections (for them) to provide services to its occupants and facilitate remote home control [1]-[3]. Thus, homeowners can control their home appliances remotely and monitor their statuses. Regarding some issues of adoption and also the potential opportunities of SHT (smart home technologies), research and development of SHT can focus on two aspects, that include technical development and how technology can be adopted and diffused into the market or society. Firstly, SHT aims to improve the quality of life at home by giving more convenient services and additional features. Secondly, this technology is used as an enhancement of a building system for better use of energy and to improve the house utilities.

The smart home system includes features that are very intelligent in today's human life and its more detailed objectives are controlling home appliances, securing connection channels between application and the embedded system, streaming real-time video from web camera or security camera, promoting home safety, and providing energy-efficient feature [4]. In smart home automation, the control of the connected household appliances can be carried out using smartphones [5], [6]. As wireless communication technologies have developed rapidly in recent years, it is possible to access or control household equipment remotely [7], [8].

Smart home is one of the applications of the internet of things (IoT), although IoT is also used in other areas such as in transport and traffic management [9]-[12]. The implementation of IoT for smart homes has become one of the most discussed IoT-related research areas and previous research also indicated that there was a growing number of home/household devices connected to the Internet via smartphones [13]-[15]. Also, huge data is generated by smart home devices. There are growing concerns, but previous work did not address enough to manage and analyze home data. Smart home categorization is based on focus areas, such as energy, information and communication, security, health, environment, home entertainment, and household appliances [16], [17]. In terms of energy efficiency in smart homes, several issues should be taken into consideration, i.e. energy consumption monitoring system, energy usage management, and capability for processing data related to the energy consumption around the house [6].

2. RESEARCH METHOD

The utilization of the artificial neural system is broader than when it was first introduced. ADALINE has several advantages, including using a linear transfer function instead of the hard-limiting one. Thus, the output can vary. ADALINE also responds to changes in its environment when it is operating. It is not only used in laboratory applications that are more likely to be based on pure science but can also be utilized in more applicable fields. Usability will be more visible if the user requires the application of artificial intelligence such as expert systems, knowledge-based systems, and decision support systems. When compared to self organizing maps (SOM), ADALINE has a different paradigm. SOM belongs to the unsupervised learning paradigm, meanwhile, ADALINE uses the supervised learning mechanism. The use of supervised learning is widely implemented on a more limited scale, but for monitoring and controlling larger quantities of smart equipment simultaneously SOM/unsupervised learning method is considered more suitable. An artificial neural network (ANN) is a network that comprises small processing units. It is a model designed to imitate human neural networks. It is an adaptive system that can change its structure to solve problems based on external or internal information that flows through the network. Simply stated, ANN is a non-linear statistical data modeling tool. that can be used to model complex relationships between inputs and outputs for finding patterns in data. Artificial neural networks are networks of small interconnected processing units, which are modeled based on neural networks. The artificial neural system is also an information processing system that has a way of working and characteristics such as neural networks in living things. This was later developed as a generalization of mathematical modeling that is patterned on the human cognitive nerve. This system will carry out derivative learning to achieve convergence. It can also be said that an artificial nervous system is a tool commonly used and applied to predict and classify. The testing algorithm for ADALINE is:

- Obtain weight from the learning process. Weight Initialization (w).
- For each bipolar input in x vector:
  a) Set activation of the input unit x_i $(i = 1, ..., n)$
  b) Calculate network value (netval) from input to output

$$netval = \sum_i x_i w_i + b \tag{1}$$

$$y = f(netval) = netval = \sum_i x_i w_i + b \tag{2}$$

Where:
$netval$ = network value
b = biased value
X_i = input data
W_i = Weight value
y = output

To model and match the data patterns of daily electricity consumption based on the ADALINE method, the daily energy consumption pattern is defined based on time and date. Then, it is compared with the actual data. The methodology for implementing ADALINE for the prototype is shown in Figure 1, as follows.

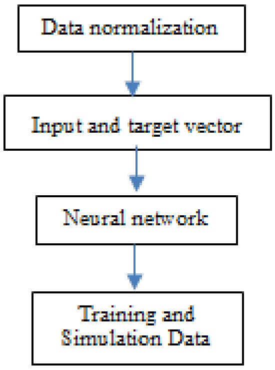

Figure 1. ADALINE testing methodology

This study has identified the problem that less implementation of an ANN system model as a mobile system that allows setting the home appliances control in one interface [18]. Normally in previous research only had automatic control, but did not yet have any function for monitoring home appliances such as a lamp, temperature, air conditioning (AC), and television (TV) [18]-[21]. The designed science and technology for humanity (STH) applies adaptive linear neural network (ADALINE) as its method, IoT, and utilizes microcontrollers, sensors, and several other supporting electronic devices [21], [22]. This microcontroller method is the hardware used to obtain a lamp controller while the ADALINE method is to get an artificial nervous system model into a system [23]-[25]. Another one is the outcomes of the smart dryer prototype can be integrated with the model of an artificial nervous system using ADALINE [26]. This prototype design initiates by inventing a scenario design to discuss the tools used and the connection between software and hardware. Software design assists in the flow of the program to be invented by connecting hardware tools, whereas hardware design is utilized to place each part that will be used [27], [28]. When this home appliances-control application has been designed, the control system is then tested to define the compliance of the application that has been made [29].

As seen in Figure 1, the ADALINE model is utilized for training the process of artificial neural networks. The targets and inputs are trained with a network that has been developed to get the learning weights to be utilized as the fundamental for calculations on the following incoming training data [30]. If the stages of normalization have been implemented, the data is ready to be processed into the ADALINE neural network [31]. When entering target data and input data as training data, the testing is performed using a neural network tool in the Matlab application and begins to create networks by training on target data and input data. From a technical point of view, several aspects need to be developed namely the user interface, smart hardware, and their software platform [32].

3. RESULTS AND DISCUSSION

Figure 2 shows the circuit design of the smart home system with a solar panel. The access point is used for internetwork and Raspberry Pi serves as the webserver. The mechanism of solar panels is by converting solar energy into electric current, also known as photovoltaic systems. The battery is used to store the current electricity and supply it to the household appliances as the alternative power source in the event of a power outage. The Smartphone is used as the client that can control home appliances such as choose TV Channels, turn the lights on and off, and change the speed of fan or air conditioner. The process of the client is by retrieving data to open the HTML5 Framework from the Raspberry as a computer server, both of which are connected to the access point. HyperText markup language (HTML) is used as contents written in it are easily accessed by the browsers and it offers more efficient coding. And then the Android client processes AC/Fan, the turn on and off lights, TV channel by pressing the ON button on the interface and sending this command to the access point then received by the server. As the server gives the command to the Ethernet Shield then passes it to the microcontroller, the command is received by the relay and the light will turn on. The circuit requires one chip of Raspberry as the microcontroller. The Raspberry serves as the server of data sent by the smartphone client, then forwards the command to the devices via the access point. Access points work as an intermediary between software and hardware (devices) in the process of controlling the appliances.

Figure 2. The circuit design of the smart home system

The process of this prototype is to model and match the data patterns of daily consumption of electrcal energy based on the adaptive linear artificial neural network method so that the definition of electrical energy daily consumption patterns based, then compare with the actual data. Tables 1 and 2 shows the behavior of the electrical load on the transmission line for electricity consumption in the area of Java, Bali, and Madura. This data was observed every hour daily for one month, in December. Thus, the dimension of the vector-matrix used for the simulation is 31 days by 24 hours, or 31 x 24.

Table 1. Average monthly power consumption megawatt (MW) in Java, Bali, Madura (12:30 AM – 6:00 AM)

	HOUR											
DATE	12:30 AM	1:00 AM	1:30 AM	2:00 AM	2:30 AM	3:00 AM	3:30 AM	4:00 AM	4:30 AM	5:00 AM	5:30 AM	6:00 AM
1	12,124	12,086	11,862	11,672	11,487	11,381	11,343	11,357	11,451	11,520	11,254	10,468
2	10,867	10,741	10,659	10,466	10,399	10,422	10,454	10,558	10,793	11,019	10,951	10,660
3	11,596	11,374	11,285	11,169	10,973	11,012	11,003	11,057	11,320	11,485	11,300	10,907
4	11,915	11,716	11,629	11,567	11,446	11,432	11,281	11,434	11,809	12,160	12,271	11,908
5	12,960	12,783	12,682	12,527	12,544	12,381	12,351	12,456	12,741	13,129	13,242	12,752
6	13,304	13,119	13,020	12,833	12,783	13,035	12,854	12,914	13,393	13,686	13,885	13,671
7	13,484	13,269	13,131	12,952	12,890	12,713	12,723	13,064	13,144	13,484	13,651	13,371
8	13,255	13,141	12,949	12,845	12,761	12,644	12,611	12,660	12,870	13,293	13,477	13,262
9	13,305	13,058	12,896	12,729	12,406	12,248	12,191	12,255	12,528	13,082	13,116	12,770
10	12,326	12,110	12,065	12,056	11,860	11,862	11,806	11,827	12,149	12,283	12,403	11,816
11	12,160	11,995	11,892	11,806	11,659	11,591	11,570	11,706	11,921	12,587	12,754	12,630
12	13,421	13,120	13,103	12,776	12,769	12,633	12,571	12,729	13,100	13,513	13,615	12,980
13	13,383	13,036	12,986	12,886	12,634	12,610	12,380	12,536	12,944	13,264	13,673	13,485
14	13,375	13,133	13,051	12,894	12,716	12,627	12,544	12,625	13,007	13,431	13,520	13,511
15	12,922	12,840	12,675	12,484	12,437	12,340	12,245	12,382	12,647	13,158	13,504	13,315
16	13,282	13,082	12,865	12,661	12,563	12,530	12,402	12,428	12,862	13,233	13,358	12,933
17	12,384	12,259	12,124	11,996	11,824	11,758	11,535	11,638	11,899	12,206	12,247	11,718
18	11,845	11,660	11,564	11,484	11,233	11,279	11,216	11,217	11,610	12,167	12,337	12,295
19	13,224	12,986	12,793	12,831	12,639	12,652	12,510	12,580	12,838	13,313	13,559	13,245
20	13,183	12,991	12,989	12,834	12,675	12,487	12,456	12,519	12,737	13,288	13,675	13,463
21	13,262	13,139	12,817	12,609	12,561	12,508	12,383	12,414	12,805	13,231	13,334	13,374
22	13,292	13,142	12,988	12,829	12,801	12,618	12,572	12,501	12,964	13,284	13,704	13,320
23	13,240	13,045	12,815	12,710	12,601	12,598	12,353	12,467	12,730	13,152	13,461	12,921
24	12,859	12,485	12,356	12,240	12,252	12,029	11,957	11,938	12,334	12,419	12,673	12,018
25	12,433	12,243	12,139	11,925	11,739	11,740	11,745	11,786	12,097	12,583	12,889	12,569
26	13,304	13,072	12,941	12,914	12,713	12,638	12,612	12,589	13,035	13,417	13,755	13,388
27	13,349	13,121	13,059	12,794	12,872	12,674	12,648	12,756	12,974	13,531	13,931	13,437
28	13,351	13,252	13,176	12,930	12,807	12,644	12,689	12,673	13,087	13,336	13,746	13,426
29	13,633	13,421	13,347	13,210	13,016	12,806	12,783	12,918	13,268	13,567	13,881	13,644
30	13,531	13,308	13,071	12,970	12,777	12,684	12,712	12,814	13,060	13,314	13,566	13,042
31	12,486	12,309	11,986	12,037	11,929	11,654	11,668	11,837	11,955	12,306	12,439	11,990

Table 2. Average monthly power consumption megawatt (MW) in Java, Bali, Madura (6:30 AM – 12:00 PM)

	HOUR											
DATE	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM
1	9,848	9,445	9,663	9,649	9,610	9,583	9,634	9,972	10,014	10,106	10,072	9,889
2	10,357	10,383	10,687	10,997	11,338	11,691	11,808	12,184	12,095	12,120	12,129	11,963
3	10,756	10,437	10,697	10,706	11,037	11,157	11,290	11,503	11,594	11,697	11,636	11,580
4	11,787	12,071	12,673	13,412	14,146	14,467	14,677	14,768	15,123	15,398	15,227	14,719
5	12,433	12,585	13,185	13,734	14,402	14,329	14,925	15,188	15,335	15,429	15,348	14,671
6	13,258	13,193	13,807	14,207	14,744	14,979	15,157	15,459	15,418	15,575	15,416	14,906
7	13,015	12,994	13,687	14,008	14,690	14,974	15,168	15,186	15,399	15,363	15,407	15,278
8	12,908	12,922	13,453	14,160	14,631	14,947	15,114	15,327	15,447	15,293	14,756	13,760
9	12,327	12,324	12,436	12,988	13,490	13,687	13,893	13,946	14,113	14,131	14,089	13,531
10	11,486	11,272	11,116	11,418	11,602	11,675	11,715	11,855	11,966	12,012	11,903	11,630
11	12,190	12,219	13,117	13,554	14,358	14,530	14,997	15,095	15,301	15,257	15,248	14,664
12	12,936	12,798	13,682	14,056	14,575	14,903	14,951	15,117	15,441	15,354	15,296	14,427
13	13,163	13,066	13,560	14,061	14,766	14,943	15,067	15,199	15,243	14,947	14,949	14,126
14	13,159	12,944	13,544	14,197	14,593	14,950	15,041	15,186	15,311	15,380	15,232	14,598
15	12,954	12,795	13,464	13,953	14,261	14,695	14,568	14,852	15,046	15,048	14,443	13,608
16	12,492	12,117	12,591	12,990	13,370	13,511	13,565	13,921	14,126	14,165	14,007	13,373
17	11,412	11,152	11,250	11,355	11,614	11,672	11,897	11,834	11,861	11,921	11,853	11,589
18	12,009	12,098	12,810	13,454	13,945	14,199	14,397	14,622	14,778	14,872	14,767	14,348
19	13,017	13,043	13,491	14,009	14,530	14,660	14,869	15,040	15,131	15,216	15,042	14,398
20	13,075	12,962	13,656	13,984	14,633	14,896	14,982	15,315	15,346	15,292	15,343	14,636
21	13,222	13,070	13,465	14,005	14,596	14,952	15,052	15,100	15,401	15,351	15,193	14,456
22	12,993	12,974	13,461	14,097	14,366	14,893	15,013	15,290	15,479	15,430	14,870	13,907
23	12,555	12,180	12,558	13,158	13,546	13,776	13,994	14,140	14,426	14,506	14,118	13,758
24	11,585	11,393	11,558	11,636	11,896	11,933	12,168	12,362	12,420	12,509	12,293	12,068
25	12,488	12,397	13,153	13,775	14,453	14,728	14,862	14,946	15,300	15,267	15,166	14,475
26	13,257	13,222	13,646	14,599	15,064	15,085	15,099	15,210	15,653	15,359	15,224	14,755
27	13,037	13,041	13,673	14,304	14,857	15,265	15,298	15,572	15,605	15,644	15,656	14,991
28	13,207	13,276	13,641	14,223	14,753	15,057	15,177	15,521	15,631	15,463	15,384	14,864
29	13,285	13,138	13,759	14,284	14,835	15,102	15,297	15,476	15,716	15,736	15,046	14,221
30	12,374	12,187	12,665	12,927	13,245	13,524	13,662	13,895	14,065	13,890	13,905	13,598
31	11,813	11,502	11,461	11,596	11,792	11,867	11,808	11,951	12,092	12,005	11,901	11,669

Figure 3 shows the general 24-hour electricity consumption pattern in the area of Java, Bali, and Madura. That pattern then is normalized to get a better result. Data normalization is converting the actual value into a certain value which can then be used for determining the artificial neural network model.

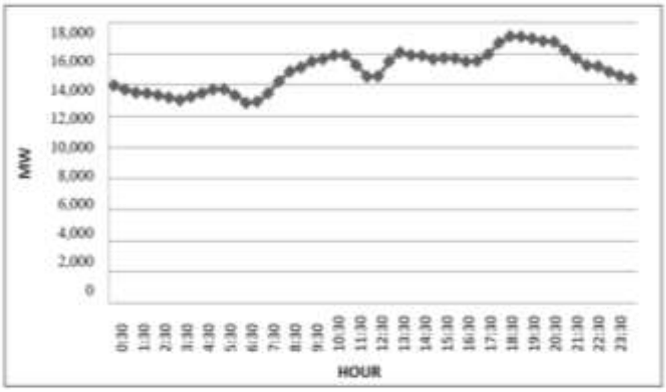

Figure 3. 24-hour electricity consumption pattern

In this case, the data will be normalized into 0 (zero) or 1 (one). The result of the data normalization presented in the general pattern of daily electrical behavior as seen in Figure 4.

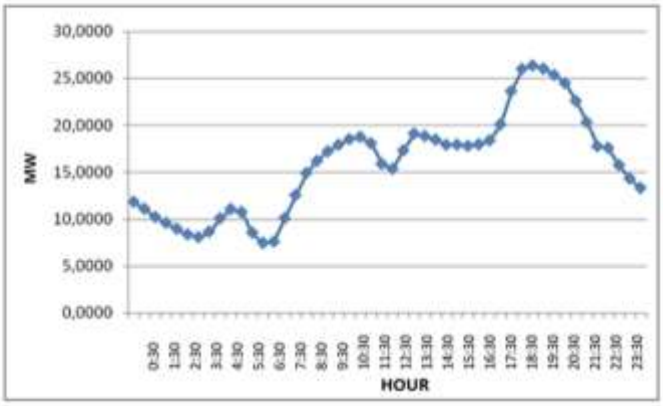

Figure 4. The general pattern of daily electrical behavior every hour after normalization

In artificial neural networks based on supervised learning paradigms, in general, 3 (three) matrices are needed. These matrices function as training data that requires training matrices and target matrices. Another matrix is a simulation matrix. Generally depicted as shown in Figure 4. These three matrices will be taken respectively based on hourly load patterns and daily load patterns. In the case of load behavior patterns, the training matrix is a 31 x 2 matrix for load behavior based on per 30 minutes in 24 hours. There is also a 24 x 2 matrix for load behavior based on weekdays and holidays. The training matrix is taken from the largest value and the smallest value from the normalized load behavior data matrix column.

4. CONCLUSION

This research was undertaken to design and evaluate that neural network algorithm namely ADALINE can be implemented to control household appliances as an integrated smart home system with a solar panel. When the system works automatically based on the readings of the existing sensors, ADALINE is used according to that condition in this study. This system can be controlled via Android applications that act as remote controls when in manual mode. To enable the operation of this prototype, one microcontroller is required as controller and server. The access point is needed to control all the media connected to the smart system. Integrating android-based components and applications is expected to increase the flexibility (for users) in controlling home appliances. Over and above that, the automatic controller of household devices based on sensor readings is expected to increase the efficiency of electricity usage. Based on testing and findings from the results of this study, that the IoT smart home model with the ADALINE method can be a model recommendation, as a proposal to obtain an efficient and beneficial electricity usage pattern to be implemented in a smart home.

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