A Fuzzy Neural Network Recognition Model of Home Network Events

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Abstract

In this study, we proposed a fuzzy neural network recognition model of home network events. We applied fuzzy neural network to recognize the home network events and assist the intelligent agent of information appliances to simplify the IA control rules in home network. Via the proposed model, we can supervise the home network environment conveniently.

Keywords: Fuzzy neural network; Information appliances; Pattern recognition

1. Introduction

With the dawning of post-PC age, information appliances (IAs) get to play an important role in information integration in the future. Although information appliances are coming out in greater variety and are offering many innovative functions, in order to improve the overall performance, an interactive control mechanism is more important. Since every family has different life styles, the control mechanism of IAs can't be standardized. It needs to have the capability of self-learning and inferences which can adapt to the changing of family networks and meet users' needs.

In the filed of IAs control, Lee and Huang [1] proposed the home management broker (HMB) for IA devices control. This is the most forward study of whole IA control in the home network. Kim et al. [5] developed a home network system using UPnP middleware and a compact embedded interface device for network home appliances. Lee et al. [3] came up with the idea of IAs intelligent agent model (IAIA) making home environments safer and more convenient. Lee et al. [3] proposed an IA fuzzy neural network model (FNNIS) under supervising of IAIA. This model has the functions of self-learning, and enabling IAIA to maximize efficiency of IAs. As mentioned above, the IA control mechanism is based on IA message analysis and learning to have the goal of intelligent control.

There are many events happened in the home environment anytime, some are normal events, such as sultry event, moist event, etc., the others are exception events, such as fire exception event, secure exception event, etc. The event is composed with many IA messages. For simplifying IA control rules, we apply the pattern recognition mechanism to recognize the events.

In [6], patterns recognition are cognitive tasks that humans perform more efficient than machines. Such tasks are intrinsically better suited to methodologies that work in a manner more similar to the way humans think or act. Theories of artificial neural networks, fuzzy sets and neuro-fuzzy computing have shown great promise in these areas by providing a more natural setting for obtaining approximate solutions of real life ambiguous problems.

In this study, we proposed a fuzzy neural network recognition model of home network events. We applied fuzzy neural network to recognize the home network events and assist the intelligent agent of information appliances to simplify the IA control rules in home network environment. Via the proposed model, we can supervise the home network environment more convenient.

2. Intelligent Agent of Information Appliances

The proposed home network model is based on the model proposed by Lee and Huang and further extended the idea of control [2]. The controlling and

managing of IAs are the fundamental functions of intelligent agent. The interaction among home management broker, IA devices and intelligent agent is shown in Figure 1.

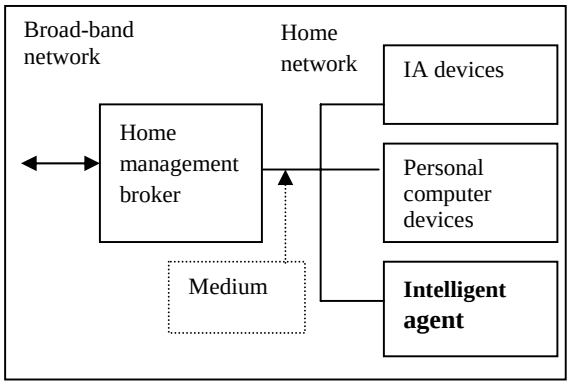

Figure 1 Structure of home network model [1]

Lee et al. [2] proposed an intelligent agent of information appliances (IAIA) and explained the processing procedure of intelligent agent and the tracking system of the exceptional event of IA devices. There are five steps taken by intelligent agent in processing, as shown in Figure 2. To make the intelligent agent more flexible, there are pre-set values for threshold values, users are also allowed to change the values. For more details, please refer to Lee et al. [2].

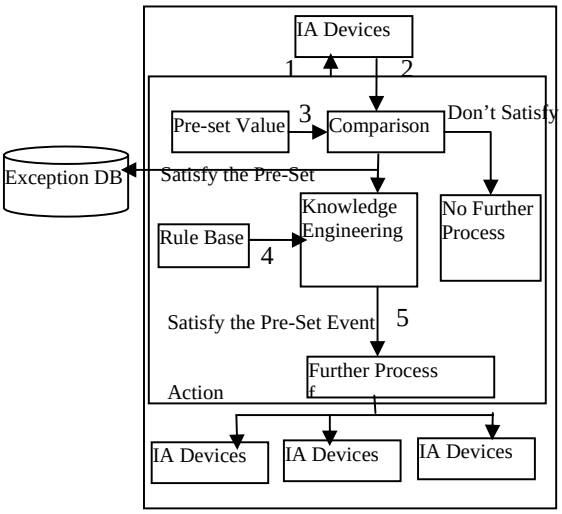

Figure 2 Intelligent agent of information appliances [2]

If the IAIA can automatically generate the rule base, and infer according to the events, then it will simplify the controlling procedures and enhance the automatic controlling capability.

3. Framework of the Proposed Model

In this section, we presented a recognition model of information appliances (IARM). IARM is built in the intelligent agent of information appliances (IAIA) and it can communicate the IA messages with IACM of IAIA, as shown in Figure 3. There are two sub-models in IARM, saying fuzzy neural network recognition sub-model (FNNR) and IA hybrid event inference sub-model (IAEI). Also, there is a rule base (RB) provided the knowledge for IAEI inferences. This model is shown in Figure 4.

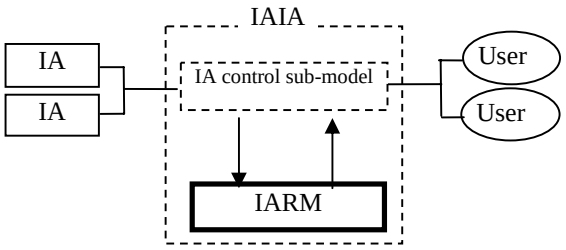

Figure 3 Context of IARM

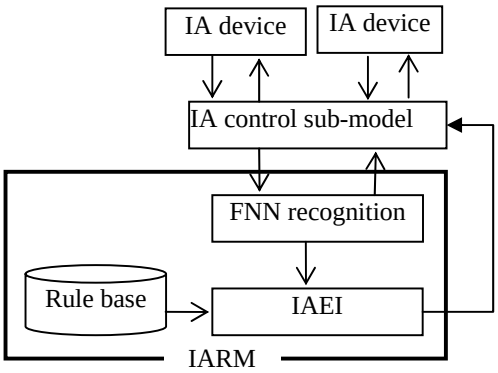

Figure 4 Framework of the proposed model (IARM)

The functions of these sub-models are as the follows:

- FNN recognition sub-model (FNNR): It can recognize the home events pattern happened in the home network environment.
- IA hybrid event inference sub-model (IAEI): It can process the event recognized from FNN recognition sub-model.
- Rule Base: The rule base store a lot of IA control rules built up from home users or IA vendors.

3.1. FNN Recognition sub-model

The FNN recognition sub-model can recognize the home events pattern happened in the home network environment. In this study, we apply fuzzy MLP model proposed by Pal and Mitra [7] to construct the FNN recognition sub-model.

In [8], the fuzzy MLP model incorporates fuzziness at the input and output levels of the MLP, and is capable of handling exact or inexact forms of input data. Any input feature values are described in terms of some combination of membership values in the linguistic property sets low (L), medium (M), and high (H). Class membership values (m) of event patterns are represented at the output layer of the fuzzy MLP. During the training, the weights are updated by back-propagating errors with respect to these membership values such that the contribution of uncertain vectors is automatically reduced. A schematic diagram depicting the whole procedure is provided in Figure 5 [7].

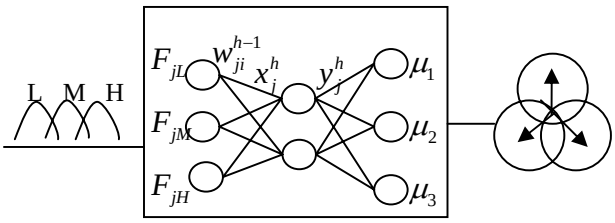

Figure 5 Block diagram of classification phase of fuzzy MLP [7]

In this sub-model, there are two operational modes which are learning mode and recognizing mode. In learning mode, users or IA vendors should learn a pair of input and output pattern event data which is common users' recognition. In the recognizing mode, the IA messages are input to the FNN automatically. After FNN processes, we can get the every event membership function as output. At last, we can obtain the most possible home event by FNN.

The FNN recognition sub-model can transform different kinds of IAs messages Sv_i to input data pattern Dv_k. Dv_k is shown as Formula (1).

$$Dv_k = (Sv_1, Sv_2, Sv_3, ..., Sv_n) \quad (1)$$

There are *m* kinds of events which are indicated in this sub-model. The output class Cv_j are composed by *m* pairs of the event E_j and the corresponding membership function of E_j is Em_j. The output class Cv_j is shown as Formula (2).

$$Cvj = \{(E_1, Em_1), (E_2, Em_2), ..., (E_j, Em_j)\} \quad (2)$$

The result of this sub-model is selected the maximum Em_j of event E_j.

3.2 IA Hybrid Event Inference Module

There are three components in IA hybrid event inference sub-model (IAEI), saying, IA exception event evaluator (IAEE), exception event inference engine (EEIE) and fuzzy inference engine (FIE), as shown in Figure 6.

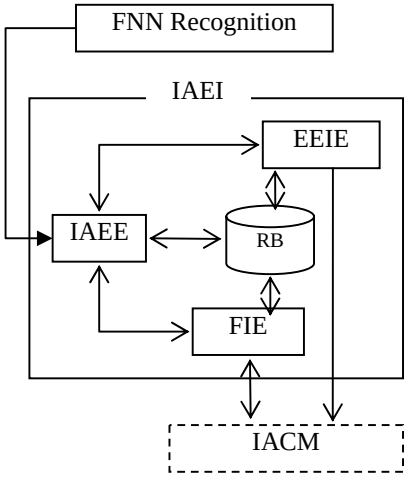

Figure 6 Information appliance hybrid event inference sub-model

IA exception event evaluator (IAEE) can get the IA event status from FNN recognition sub-model, and can evaluate the IA event which belongs to either exception event or normal event. Exception event inference engine (EEIE) can infer the appropriate corresponding process to handle the exception event. Fuzzy inference engine (FIE) applies the fuzzy inference method to handle the normal event in the home network, and control the IA automatically. IA control rule base stores the processing rules of event, including exception event and normal event processing rules.

In [6], the Sugeno fuzzy model is an effort to develop a systematic approach to generate fuzzy rules from a given input-output data set. We apply the Sugeno fuzzy model [6] in FIE. The IA control rule is the form as shown in formula (3).

$$if\ Sv_p\ is\ A\ and\ Sv_q\ is\ B\ then\ Cv_s = f(x,y) \quad (3)$$

In (3), *A* and *B* are fuzzy sets in the antecedent; *Svp* and *Svq* are the linguistic variables. *Cvs* is the control value of IA in the resulting.

Once FIE receives events from IAEE, it will fuzzify the event to linguistic variable with linguistic value. Then, it looks for the appropriate control rules for inferences. Finally, FIE responses the inference result to IACM for realistic IA control operation.

4. Implementation

In this section, we illustrate the implementation environment of the proposed model, and implement the home temperature controlling to illustrate and analyze the operation of this model as an example.

4.1 Implementation Environment

For the purpose of ease manipulation, cross-platform, and remote-control capability, we have adopted Java Server Page (JSP) and Java Servlet written Web Server structure, as well, Java 2 Platform, Standard Edition, v 1.4.2 API Specification is utilized for constructing proposed model. This model is constructed upon Tomcat server software that employs browsers as interface. Above mentioned are done with a Pentium III 700GHz Notebook that is powered by O/S Windows Professional and Microsoft Access 2002 database.

4.2 Practice examples

In this study, we apply the data set illustrated as Lee et al. [4] for implementing the proposed model. This data set included three input factors, temperature (T), humidity (H), and visibility (V). The control result of this study is an event description as shown in Table 1. In Table 1, AC+ means the increasing degrees for the air condition; AC- means the decreasing degrees for the air condition.

5. Conclusion

In this proposed model, we apply fuzzy neural network to recognize the home network events and assist the intelligent agent of information appliances to simplify the IAs control rules in home network. Via the proposed model, we can supervise the home network environment more convenient.

6. References

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Table 1 Implementing result of temperature control in home network environment

T	**H**	**V**	Lee et al. [4] control output	Proposed model control output
10	60	80	AC +8.22	Cold Event
10	70	10	AC +10.23	Clammy Event
20	30	80	AC +4.5	Comfortable
30	90	30	AC -2.4	Muggy Event
40	80	40	AC -8.32	Muggy Event
85	40	50	AC -10.23	Hot Event
85	10	5	Exception	Fire Event
100	0	2	Exception	Fire Event
100	0	0	Exception	Fire Event