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物联网中基于历史上下文的决策模型

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Historical Context-Based Decision Making Model on Internet of Things

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Abstract With the further spread of the Internet of things (IOT) and pervasive computing, intelligent service that can provide intelligent decision making and forecasting applications is more and more popular. This decision making service will also become the future trend. Based on this, a historical context-based decision making model on IOT is proposed. In this model, we integrate context-aware computing, data fusion, sensor technology and multi-agent mechanism together. The proposed model consists of four levels: data awareness layer, data processing layer, decision-making layer and application layer. The implementation steps of the decision making model are described in the scene of the family health-care. It shows that the decision making model has good scalability and application prospects. It can be used for the future decision making applications in IOT and provide a unified framework for the intelligent decision making and forecasting services.

Key words context; decision making model; agent; health care; IOT

摘 要 随着物联网技术及普适计算技术的深入普及,能够提供智能决策、智能预测的应用服务越来越受到人们的追捧,而这种决策服务也必将成为未来的趋势.基于此提出一种物联网中基于历史上下文的决策模型.该模型集成上下文感知计算、数据融合技术、传感器技术和多代理机制于一体.提出该模型的四层架构:数据感知层、数据处理层、决策层和应用层,并通过家庭健康监护这个场景来说明模型的实现步骤.该决策模型具有较好的可扩展性和应用前景,能够适用于将来的物联网决策支持应用,为物联网中智能决策、预测等服务提供一个统一的框架.

关键词 上下文;决策模型;代理;健康监护;物联网

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As a part of future trends and developments, the Internet of things (IOT) will shape the society. The concept of IOT can be regarded as an extension of the existing interaction between humans and applications through the new dimension of "things" communication and integration[1-2]. The concept of the context is defined usually as the whole information which could describe the situation of an entity. As the most important research aspect of the pervasive

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computing, the study on it will bring strong promotion to the development of the pervasive computing[3-4].

Applications of context-aware computing can discover and take advantage of contextual information. In the future, applications of WSN are envisioned to adapt the applications' behaviors by utilizing various contexts of environment and its users. The context information may often be ambiguous and also heterogeneous, which make the delivery of unambiguous context information to real applications extremely challenging. But little work has been devoted on the research of context history. In our research, we propose a historical context-based decision making model. Using context history, the model is able to be triggered to emergency response or recommend navigation and service[5-7].

1 Key Technology

1.1 Context-aware Computing

This model combines context-aware computing which can handle, get and analyze the context information [8], including the five sub-technologies: 1) context-getting; 2) context-modeling; 3) context-reasoning; 4) context-conflict-solving; 5) context-storage and management.

One of the limitations of the previous context-aware application is only considering the current context. Context history has many possibilities to improve the services. If the context history can be used, the personalized and intelligent services can be provided to the users by extracting users' patterns from context history. Context history has been used for the prediction of future context, selection of devices and adaptation[9-10].

1.2 Data Fusion

The technologies of data fusion are as followed: 1) data conversion; 2) data related; 3) state database; 4) fusion reasoning; 5) fusion loss.

In most data fusion systems, the information extracted from sensors is represented as measures of belief in an event. The sensors may be dynamically configurable, and may produce ranges with error estimates. The knowledge will certainly be dynamically configurable, depending on the state of the system.

1.3 Multi-agent

Agent is an entity to complete a particular job in a particular environment without manual intervention and oversight. Agent is adaptive, intelligent and collaborative. Agents can not only complete their work independently, but also collaborate with other agents to complete a task. Agent here mainly refers to software agent. Multi-agent technology is the structure formed by a number of agents, to solve the complex problems which a single agent cannot solve [11-12].

Agent-based computing has been a new paradigm in software applications development and there are some characteristics for intelligent agents, such as autonomy, adaptation and cooperation. Multi-agent systems consist of the various agents that execute each goals.

2 Architecture

The historical context-based decision making model has four layers. Furthermore, each layer has its own agents to execute each goal.

1) Data awareness layer: collecting the rough context information and user context, including awareness agent and user agent.

2) Data processing layer: refining the rough context and fusing the context information based the user profile, including context refining agent and context fusion agent.

3) Decision-making layer: based on the context history to make decisions, including decision making agent.

4) Application layer: the application is triggered by the trigger agent.

The Fig. 1 below shows the architecture of the decision making model.

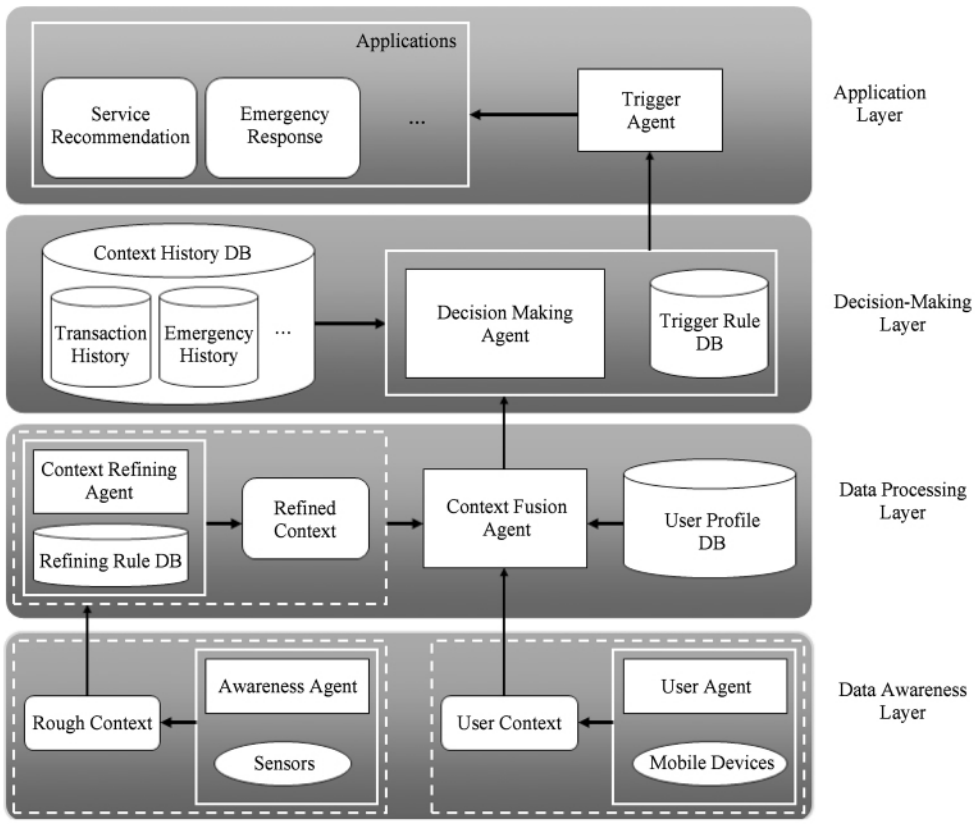

Fig. 1 Architecture of the decision making model.

2.1 Data Awareness Layer

Data awareness layer takes charge of collecting rough context and user context. In this layer, the awareness agent is used for gathering rough context from the sensors, such as time, temperature, location, etc. The user agent is used for gathering the user context.

The rough context could affect the decision making. The user context is managed in the context history DB. So the user context must be sent to context history DB in decision-making layer.

2.2 Data Processing Layer

In this layer, all of the context information is fused into an overall context, which is provided for the decision making agent in decision-making layer. To start with, the rough context from data awareness layer should be refined based on the refining rules in the database.

Once the context refining agent receives the rough context, including controlling the accuracy of measured information and eliminating the ambiguity of multi-source data. The context refining agent unifies the format of context to make them to be identified. The rules are stored in refining rules DB. It consists of context reason engine, context receiving engine and context module engine. Another difficulty is context fusion. This is executed by the context fusion agent.

2.3 Decision-making Layer

The decision is made in this layer by decision making agent. In addition, this layer manages context history database. This database composes the users' decision-making histories. Once decision making agent receives the fused context data, it maps the situations in context history DB to find possible treatments or service recommendation. The agent also can exclude some emergency mistakes through the history of special times, special locations or special situations.

Ultimately, the agent executes decision-making and triggers trigger agent in application layer according to the trigger rules in DB.

2.4 Application Layer

Application layer processes the feedback of the user for the recommended services or provides responses of emergencies to mobile devices.

The trigger agent is used for receiving the decision which is made by decision making agent and triggering the mobile devices, some equipment or institutions to execute the applications.

3 Prototype Implementation

Based on the model of multi-agent system, this paper presented an implementation model based on context-aware computing in the digital home for the elderly health-care. This model uses the context technology, through analysis of historical context and the context collecting at this time, to predict the next phase of the state of the elderly, and it can perceive in advance by the guardian or prevent the next phase of the state in intelligent health-care.

3.1 Related Definitions

Context data is accessed through the digital home in the WSN, shown in Table 1.

Table 1 Context Information

Type	Parameters	Access channels
Physiological information	temperature, pulse, ecg, blood, hypoxemia	Guardian who is wearing the wearable physiological information collection node.
State Information	acceleration, location	Guardian who is wearing sensor nodes
Environmental Information	temperature, humidity, noise, wind, smoke, flammable gas.	Sensors with different locations in the family of the digital home

Historical context are various parameters above which is obtained through the sensors and stored in the historical context database.

Target's health care should be in one of the following four states:

P_1: health status. The guardian has no disease, and the physiological parameters and state information are in the normal range:

temperature[36,37.5]; pulse[60,90]; blood, DBP〈80, SBP〉120; Hypoxemia>0.95.

P_2: slightly ill. The guardian is in sub-health state. It means most of the physiological parameters are deviated from the normal range. The custodian at this time needs reasonable exercise and diet with the related drugs to adjust the state to P_1.

P_3: seriously ill. The guardian has a severe physical disease. Physiological state is seriously deviated from the normal range. Compared with the state P_2, P_3 is a more precarious state. At this time, we should notice the guardian's private doctor as soon as possible.

P_4: the state of emergency. The guardian is in a state of a sudden emergency, such as a sudden fall, smoke, and flammable gas. The related parameters are seriously overweight. This state is easily converted to P_3. When the guardian is in this state, it needs to alarm.

The four states above are the all possible states of the guardian in this paper. To quantify the conversion rules between the four states, the paper defined the following six events. When the guardian is in the state $P\,[P_1, P_4]$, through the context information of sensor and the historical context, it will reason, test and verify to get the event $E\,[E_1, E_2, E_3, E_4, E_5, E_6]$, and then determine the next state P' of the guardian by the state transition rules to realize intelligent prediction. When the guardian is in P_3 or P_4 state, it can achieve early warning. Six states as follows:

E_1: normal. Physiological parameters are collected in the normal range.

E_2: slightly ill. It means that most of the physiological parameters are deviated from the normal range.

E_3: severely ill. The physiological parameters are collected from a serious deviation from the normal range. Combined with the historical context of the database, it shows that this event is ongoing events.

E_4: the breaking accident. The state and environmental information gathered is excepting.

E_5: recovery condition. It means that the condition of the guardian is alleviating, and transforming to the P_1, through contrasting the historical context with the physiological parameters gathered now.

E_6: disease progression. It means that the condition of the guardian is increasing, and transforming to the P_3, through contrasting the historical context with the physiological parameters gathered now.

3.2 Context Modeling

As for the context information defined in the A, this paper uses the key-value model for the modeling. The model key-value can illustrate the relative relationships between properties and their values. It is good for the store and the inquiring of the data. This paper uses the language XML to store the key-value as the key technology.

After the modeling, the information needs to be stored in the database to form the historical context. The context information in this paper will be stored in the database by the context container. In this course, the congener data will be put in an array, and every array will correspond to a table in the database. Every five collecting action will activate one database accessing operation. Every collecting time slice is two minutes and every database accessing is ten minutes.

3.3 Context Reasoning

After the context data collection, we need to do reasoning work according to some defined rules. In this paper, we evaluate the probability of the event E [1-6] through the judgments of the rules. Then we adjust them through the environment and status information in a further step to reduce the effect from the environment factor to the rules judgments. For example, we consider that the event E_2 mostly happened when the pulse is 92 with an excess in a certain measure in the monitoring. But if we also find that the position monitoring shows that the person has a float variable acceleration outdoors then it means that the person is in the movement or some sports. Then it modify the judgment as that the event E_1 has a higher priority in the occurrence probability. The reasoning course will be given in the Fig. 2 below:

$$\begin{matrix} Time\ 2 & 4 & 6 & 8 & 10 \end{matrix}$$
$$\left\{\begin{matrix} BBT_1 & BBT_2 & BBT_3 & BBT_4 & BBT_5 \\ Pul_1 & Pul_2 & Pul_3 & Pul_4 & Pul_5 \\ Hyp_1 & Hyp_2 & Hyp_3 & Hyp_4 & Hyp_5 \\ Blo_1 & Blo_2 & Blo_3 & Blo_4 & Blo_5 \\ Tem_1 & Tem_2 & Tem_3 & Tem_4 & Tem_5 \\ Hum_1 & Hum_2 & Hum_3 & Hum_4 & Hum_5 \\ Geo_1 & Geo_2 & Geo_3 & Geo_4 & Geo_5 \\ Nos_1 & Nos_2 & Nos_3 & Nos_4 & Nos_5 \\ Gas_1 & Gas_2 & Gas_3 & Gas_4 & Gas_5 \end{matrix}\right\} \begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \\ p_5 \\ p_6 \end{bmatrix}$$

Fig. 2 The reasoning course.

The P_1, P_2, P_3, P_4, P_5, P_6 in the Fig. 2 represents the probability of the event E [1-6] respectively. We will process the context transition with finding the maximum probability of the relative event E. And then we put the probability with its event calculated in this time into the historical context database and return the next status which is forecasted to the user.

3.4 Multi-agents Mechanism

We can get the better hierarchical scenario model by applying the decision making model framework into the digital home's elderly people health-care scenario. It will shield the operations of the different steps through the multi-agents mechanism. It can guarantee the safety of the data and be implemented easily only by the agents.

Data awareness layer: It can get context. Each sensor node collects the sensor data by setting agent, and the data gathered through the context server agent. Then it stores the context through the storage agent and the algorithm agent. Because of the different types of context, agent is also different, including three categories: user agent, environment agent and state agent.

Data processing layer: The context getting from the awareness layer will include a lot of redundant data. So it needs to form unified and standardized data for data modeling and reasoning. In this layer, it includes three agents. Communication agent, which is responsible for collecting data from the data awareness layer, and transmitting data to the upper decision making layer; fusion agent needs to fuse the physiological information, environmental information and state information. The context refining agent is responsible in modeling the context through the context fusion agent.

Decision-making layer: At this layer, it consists of three agents, namely: DB agent, decision-making agent and communication agent. DB agent maintains the context of database-related operations. The standard physiological parameter information, status information and environmental information is stored in the database. It also provides historical data for decision-making agent. Decision-making agent is responsible for reasoning and verification based on the methods described in the section 3.3. It obtains the events E of the guardian at this moment, and then gets the state P at next moment. Finally, it passes the result to the application agent through the communication agent.

Application layer: This layer is the application level, including application agent and communication agent. Application agent obtains the decision passed from communication agent in decision-making layer, and then collates the results and shows it to the user. If the situation is normal, then the results will be displayed in the form of a curve or histogram to the user. If there is an emergency, the application agent directly alarms to the 120. It will achieve the true realization of intelligent and predictive health-care.

4 Conclusion

In this paper, we proposed a historical context-based decision making model in IOT. This decision-making model has good prospects for IOT applications in the future. The next step of our research is to improve the quantitative description of the context reasoning. To compensate for the lack of semantic reasoning, we will make more accurate and intelligent reasoning algorithm. Finally, this decision making model on IOT will more comprehensive and intelligent.

References

[1] Amardeo C Sarma, João Girão. Identities in the future internet of things. Wireless Personal Communications, 2009, 49(3): 353-363

[2] ITU Internet Reports 2005: The Internet of Things. [2011-04-15]. http://www.itu.int/internetofthings/

[3] Weiser M. The computer for the 21st century. Scientific American, 1991, 265(3): 66-75

[4] Anind K Dey. Understanding and using context. Personal and Ubiquitous Computing Journal, 2001, 5(1): 4-7

[5] Paul Castro, Richard Muntz. Managing context data for smart spaces. IEEE Personal Communications, 2000, 7(5): 44-46

[6] Dey A K, et al. Towards a better understanding of context and context-awareness //Handheld and Ubiquitous Computing, 1707. Berlin: Springer, 1999: 304-307

[7] Chen Guanlin, Kotz David. A survey of context-aware mobile computing research, TR2000-381. Department of Computer Science, Dartmouth College, 2000

[8] Lu Yan, Sere K. A formalism for context-aware mobile computing //Proc IEEE ISPDC/HeteroPar'04. Piscataway, NJ: IEEE, 2004

[9] Hee Eon Byun, Keith Cheverst. Utilizing context history to provide dynamic adaptations. Applied Artificial Intelligence, 2004, 18(6): 533-548

[10] Mohamed Khedr, Ahmed Karmouch. Negotiating context information in context-aware systems. IEEE Intelligent Systems, 2004, 19(6): 21-29

[11] Khedr M, Karmouch A. Acai: Agent-based context-aware infrastructure for spontaneous applications. Network and Computer Applications, 2005, 28(1): 19-44

[12] Zhu Miaoliang, Qiu Yu. A survey of mobile agent system. Journal of Computer Research and Development, 2001, 38(1): 16-25

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