Development of Smart Sensors System Based on Formal Concept Analysis and Ontology Model

* **Hongsheng Xu, Ruiling Zhang**

College of Information Technology, Luoyang Normal University, Henan Luo Yang, 471022, China
*Tel.: 0086+13403793403
*E-mail: xhs_ls@sina.com

Abstract: The smart sensor is the product of the combination of one or more sensitive components, precision analog circuits, digital circuits, microprocessor, communication interface, intelligent software systems and hardware integration in a packaging component. Formal concept analysis is from the given data to automatically extract the classification relationship between the entire hidden concept and concept, formation of concept model. Ontology is a set of relations between concepts of the specific domain and concept, and it can effectively express the general knowledge of specific field. The paper proposes development of smart sensors system based on formal concept analysis and ontology model. Smart sensor is a micro processor, sensor with information detection, information processing, information memory, logical thinking and judging function. The methods can improve the effect of the smart sensors. *Copyright © 2013 IFSA.*

Keywords: Smart sensors, Formal concept analysis, Ontology.

1. Introduction

The sensor system is the combination of sensors, computers and communication technologies. Intelligent sensor systems and micro-sensor system is one of the two main research directions. Three ways to achieve a smart sensor: (1) non-integrated implementation (2) integration (3) hybrid implementation. integrated smart sensor has three existing forms: the primary form of Intermediate forms / self-reliance in the form. The primary form of micro-processing is unit. the so-called smart sensors, one with unused processors can a combination of both monitoring information and information processing capabilities of the sensor, the sensor (signal conditioning circuit) is given in the microprocessor rich, both monitoring and information processing functions sensor smart sensors. The real world there are a variety of objects,

each object has its own set of attributes or characteristics of concept lattice structure reflects the links between objects and attributes, and generalization of the concept with the example of the relationship between a complete conceptual level structure.

The intelligent sensors are a sensor having an information processing function. Smart sensor with a microprocessor, acquisition, processing, ability to exchange information, the sensor integrated microprocessor combined product [1]. Feeling of general intelligent robot system consists of multiple sensors collection, collected information needs to the computer for processing, and the use of smart sensors can be distributed processing, thereby reducing costs.

Ontology concepts are from the field of philosophy. The earliest introduction of the concept of the body is the field of artificial intelligence (Al). The introduction of the field of artificial intelligence

body is to address issues related to knowledge representation and organization. Ontology concepts and methods into knowledge organizations and the field of Library and Information in early 2000. The introduction of ontology are to address the problem of information retrieval, resource organizations.

Smart sensors (also known as digital sensor) is to come out in the mid-1990s, it is the crystallization of microelectronic technology, computer technology, and automatic test technology (ATE). At present, the international community has developed a variety of smart sensor products. Within the smart sensor contains a sensor, A / D converter, the signal processor, a memory (or register) and an interface circuit. Some products also with a multiplexer, the central controller (CPU), random access memory (RAM) and read-only memory (ROM).Features of the smart sensor is able to output measurement data and the amount of control, fit a variety of microcontroller (MCU); and it is on the basis of hardware and software to achieve the test function also depends on the degree of intelligence software the level of development.

In formal concept analysis, the concept is understood as the set of all objects belonging to this concept, and connotation is considered all of these object are common features (or attributes) set, which realizes the formal understanding of the concept of philosophy [2]. The main content of formal concept analysis is a pair of two Yuan relations among sets, namely Galois lattice or concept lattice. Each node of the concept lattice is a by the denotation and connotation of the two part of formal concept. Extension refers to examples covered by formal concept; connotation is the common feature of concepts covered instances. Smart Sensor is a microprocessor-with the sensor detection, judgment and information processing functions. Compared with conventional sensors with high accuracy, wide range, multi-function, high reliability and high stability, strong adaptability, high signal-to-noise ratio, micro-power and cost advantages. The paper proposes development of smart sensors system based on formal concept analysis and ontology model.

2. Design of Smart Sensors based on Formal Concept Analysis

MEMS technology is miniaturization, integration, sensor miniaturization and highly integrated sensor may have a lot of information detection and control functions, in order to achieve intelligent. Miniaturization, multi-functional, integrated and intelligent sensors will gradually replace traditional sensors to become the mainstream of automotive sensors based on MEMS technology.

The smart sensor is constituted by two parts of the conventional sensors and a microprocessor unit, which can be of the sensor and microprocessor integrated on a single chip constitute a monolithic smart sensor can also be a microprocessor of the

sensor is able to retroversion. A block showing is the configuration of a typical smart sensor system. The functionality of the smart sensor, the control function in the smart sensor, the measurement process can be pre-programmed program, under the control of the microcomputer automated measurements. Control general: keyboard control functions, automatic range switching function, multi-channel switching, extreme judgment and cross-border police, automatic calibration, automatic diagnostic measurement results display and print options.

The concept lattice has been found in the knowledge, software engineering, information retrieval, and many other areas widely used, but the time complexity and space complexity of the issue has been a major problem that plagued its further application [3]. The use of high-performance parallel computing and storage capacity of the computer to construct and storage is the fundamental way to solve this problem effectively. Distributed data storage and parallel processing, how rational and effective organization of distributed storage and parallel processing of data both in theory and in technology, there are many problems need to be studied.

Smart Sensor is a way to feel a measured object detection function; learning, reasoning, judgment processing signal; communication and management functions of a new class of sensors. Smart sensor automatic is zeroing, calibration, compensation, data collection capabilities. Its ability to determine the intelligent sensor also has high accuracy and resolution, high stability and reliability, better adaptability, compared to traditional sensor also has a very high cost, as is shown by equation 1.

$$\frac{du}{dx} + (1-n)P(x)u = (1-n)Q(x) \qquad (1)$$

The quality indicators for certain products (viscosity, hardness, surface finish, composition, color, taste, etc.) can not be carried out fast, direct measurement and control line in the industrial production, the use of traditional sensors. Smart sensor to directly measure a function of the production process of some quantity (such as temperature, humidity, pressure, flow and product quality indicators), calculated using the mathematical model of neural network expert system technology, which canto infer the product quality.

The concept description is to describe the meaning of a particular type of object, and outlines the relevant characteristics of such objects. The concept description divided into the description of the characteristic and distinctive Description former describes a common feature of certain types of objects, which describe the difference between different types of objects. Generate a characteristic description only relates to the commonality of all objects in the class object. Generate distinctive described in many ways, such as decision tree method, genetic algorithm.

Virtualization is a common hardware platform to make full use of the software implementation of intelligent sensor specific hardware virtualization sensors can shorten product development cycles, reduce costs, and improve reliability. Intelligent sensor network is the use of multiple sensors for a variety of bus system and is equipped with a network interface (LAN or Internet) microprocessor. Between the sensors, the sensors and actuators, sensors and systems data exchange and sharing can be achieved through the system and network processor.

Non-integrated intelligent sensor traditional sensors, signal conditioning circuits, microprocessor combination with digital bus interface as a whole constitute smart sensor system. These non-integrated smart sensors developed rapidly in the promotion of the development of the situation in the field bus control system. Automation Instrumentation manufacturer of the original set of production equipment is essentially the same, an additional microprocessor with digital bus interface flapper assembled and equipped to communicate, control, self-tuning, self-compensating, self-diagnostic smart software, enabling smart sensor function. This is one of the most economical and fastest ways to create a smart sensor [4].

$$\underline{\mathbf{B}}\left(G,M,I\right) \cong \underline{\mathbf{B}}\left(G,M\backslash\{M\},I \cap \left(G \times \left(M\backslash\{M\}\right)\right)\right). \quad (2)$$

With the rise of object-oriented programming method, to identify the object from the legacy code will undoubtedly be of great value, object recognition process normally consists of several steps: The first is to identify the heritage record as a candidate class, and then identify the heritage processor program as a candidate method, and finally through some form of clustering analysis for each method to determine the optimal class. And-Deursen by semi-automatic restructuring heritage data structure to identify objects cluster analysis and conceptual analysis in object recognition, and applied to a million lines of code COBOL system, the use of comparative analysis of these results cluster analysis of the technical and conceptual analysis techniques.

Virtualization, networking and information fusion technology are the three main directions of the development of intelligent sensor. Virtualization is the use of general hardware platform made full use of software to realize the specific hardware function of intelligent sensor; virtual sensor can shorten the product development cycle, reduce cost, and improve reliability. Networked intelligent sensor is the use of multiple sensors of various bus system components and equipped with a network interface (LAN or Internet) microprocessor. Through the system and network processor can realize sensor, sensor and actuator, sensor and between the system data exchange and sharing, as is shown by equation 3.

$$F\left(x, y, \frac{dy}{dx}, \cdots, \frac{d^{n} y}{dx^{n}}\right) = 0 \quad (3)$$

Path to realize the intelligent sensor: path to achieve non integrated implementation: non integrated implementation: common sensor with digital bus interface of the microprocessor and signal conditioning circuit are combined together as a whole constitute an intelligent sensor system, as a whole constitute an intelligent sensor system, the non integrated intelligent sensor is to promote the development situation of the field control system developed rapidly under the line. Push line control system under the development situation of rapid development.

RULEARNER Sahami development system, it firstly according to condition attribute to construct concept lattice, and then extracted from the lattice of classification rules are used to support the classification of the object; and the LEGAL-E system Njiwoua design is used for learning the parameters to generate the semi lattice part -- from the concept lattice, the space complexity and effective control of concept lattice, then the voting the way to classify new objects for group decision making; the feature selection method is applied in the LEGAL-E system, they have got the LEGAL-F classification system.

Smart sensors in the automatic control system of detection and has the equivalent of the five sense (i.e., hear, smell, taste, vision, touch and so on) the important role. Automation system function more complete, the system dependence on sensor is also greater. In the advanced control system, intelligent sensors are a key technology [5]. A new sensor not only to "signal perception" outside, but also the "perception" to the processing necessary, both excellent function of the realization of sensor is the inevitable trend of the future development of the sensor. Intelligent sensor is the result of development of science and technology, but also the need of the development of science and technology, as is shown by Fig. 1.
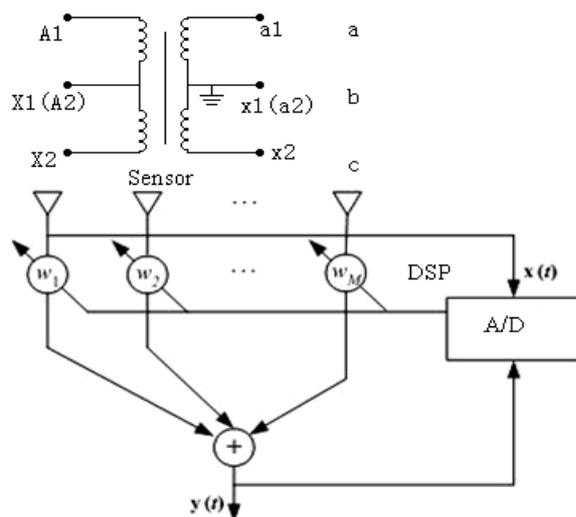

Fig. 1. The design of Smart sensors in the automatic control system of detection.

The intelligent sensor is relates to the micro mechanical and microelectronic technology, computer technology, signal processing, circuit and system, sensor technology, neural network, fuzzy theory and other disciplines integrated technology. To promote the development of intelligent instrument development main technology sensing technology A/D devices will significantly enhance the function and measurement range of single-chip microcomputer DSP instrument is widely used in ASIC, FPGA / CPLD technology of Labeler graphical software technology of network and communication technology of intelligent sensor in the future.

Formal concept analysis about was born in nineteen eighties, the team was in Germany at the beginning of the Darmstadt research and development system is an application software based on lattice theory [6]. The first description of formal concept analysis is the keynote speech in 1981 on an ordered collection of Banff meeting. Formal concept analysis appears to be a complex noun is difficult to understand, it is necessary to explain. It is a kind of analysis tools or methods of data, especially for the investigation and handling of the given information, to find hidden hiding much important information behind the data.

The smart sensor is made out of a system instead of the sense organs and organisms and expands its functionality and design. And organisms feeling have two basic functions: First, the presence or detection of the detection object conversion target signal; another judgment, reasoning, and the identification of the object's state. The former is called "sense", while the latter is referred to as "cognitive. General sensor only precise ability to "sense" of an object, rather than the ability to "know" (wisdom).Smart sensors can be "aware" and "cognitive" and played the role of "five senses" function., as is shown by equation 4.

$$\lambda p_2 = 3up_3, \; p_3 = \left(\frac{\lambda}{u}\right)^3 \frac{p_0}{3!} = \frac{\rho^3}{3!} p_0 \qquad (4)$$

The principle and structure of smart sensor is an analog signal processing and digital control (DCASP). Such as the intelligent sensor is generally divide into two parts: the sensor and information processing unit. The basic sensor is the most accurate design using DSSP structure, usually based intelligent sensor, its performance largely determines comprises two sensors: by measuring sensor (such as pressure) performance of intelligent sensor, the micro mechanical processing technology.

Application design is easier. Smart sensor object-oriented application design engineers can work focus on the application level of the system, such as control rules, user interface, ergonomics, etc., rather than the sensor itself, just as the system simple parts can be used. Applications are at a lower cost. Assisted in perfect technical support tools, applications in research and development, procurement, production

more cost. Sensing standard protocol interface, the sensor factory (including sensitive components) will focus on the quality and security of the sensor side, do not to it was required to provide customers with a large number of aided design.

Source of concept lattice is to form concepts. Concept lattice (Concept Lattice), also known as Galois, is by Professor Wille of Germany in 1982 as a mathematical theory first proposed the concept for it, find, sort and display, and it will mathematical description of philosophical concept, the description method of formal concept. The theory of concept lattice is the core data structure in formal concept analysis theory is a powerful mathematical tool, knowledge discovery and data analysis. Because the concept lattice is good mathematical properties and it is suitable for batch processing characteristics. Concept lattice and parallel processing problem for distributed memory parallel distributed data can be said to be the ideal tool [7]. So the study of concept lattice model has very important theory meaning.

Formal concept analysis is a mathematical treatment of the philosophical concept, is a way for people to organize and analyze data, the data dependencies and its structure, nature and a description of the image. In formal concept analysis, concept is understood by the connotation and extension of two parts. The concept refers to the set of all objects belonging to the concept, connotation refers to all these objects are the common features (or attributes) set, as is shown by Fig. 2.
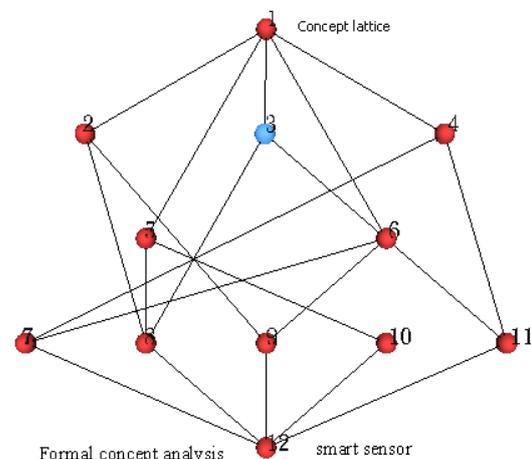

Fig. 2. Using concept lattice to build smart sensors.

Smart sensor function is through coordinated action simulation of human senses and the brain, and proposed to combine and practical experience of testing technology for long time [8]. Is a relatively independent intelligent unit, the appearance of the original hardware performance demanding mitigated, and rely on the software can help greatly improve the performance of the sensor. Intelligent sensor now has not only visual, touch, hearing, taste, and storage, logical thinking and judging ability of artificial intelligence.

Resolution refers to the sensor can detect the smallest input increment. Some sensors, when the continuous change of input, resolution refers to the smallest input increment output sensor can detect only as a step change, input amount of each "resolution is the output step" represents the size of the. The resolution expressed in absolute values, with percentage and full-scale representation called resolution input near zero in sensor resolution. Resolution called threshold of sensitivity. Threshold sensitivity refers to the ability to distinguish input near zero. Threshold sensitivity -- refers to the ability to distinguish input near zero. Refer to resolution input near zero.

The future development direction of intelligent sensor network is it. Because from the perspective of development, the future of single sensor is independent of the occasion will be less and less, to control the measurement of multiple parameters and multiple objects, more is the application of multi-sensor system. Exchange measurement and control information in the underlying mainly through the field bus, high-level data exchange is mainly through the Internet network to realize [9]. In order to meet the exchange between the multiple sensor information, sensor design software will occupy the main status, a software object is no longer a single object before, but the entire system, the output of the digital signal is in line with a certain protocol format. Through the network can be achieved between the sensor and sensor, sensor and actuator, sensor and system between the data exchange and sharing between.

Each node of the concept lattice is a formal concept, is composed of two parts: the extension, namely examples covered concept; connotation, namely, the description of the concept, the common characteristics of concept cover instances. In addition, concept lattice by Hasse figure vividly and concisely reflects the generalization and specialization relations between these concepts. And concept lattice has been applied in information retrieval, digital library, software engineering and knowledge discovery. In the field of knowledge discovery, concept lattice can be constructed from the relational data, and then the kinds of knowledge can be extracted from the concept lattice, such as the implication rules, association rules, and classification rules.

The smart sensor is a rapidly developing research area, it will inevitably make the current medical, industrial, aerospace, and consumer goods, space research, manufacturing and many other practical problems have great changes. At present stage, although the popular intelligent sensor based on micro computer, the intelligent sensor based on smart materials, namely the biosensor is still in the initial stage, but due to the interaction of relations of production and productivity, the intelligent sensor is the future development direction of sensor, it brings to all sectors of the benefits will be enormous.

3. Application of Ontology Technology in Building Smart Sensors System

Multi-sensor fusion is the best comprehensive use multi-sensor information, the intelligent system can complete the information required to complete a specific task. Multi-sensor information fusion refers to the multi-sensor information integration process are combined, the formation of an expression of a feature on the environment. Multi-sensor information has the following four characteristics: information redundancy, information complementary, real-time information, information of low cost. Fusion of multisensor integration and information in industrial robots, military, aerospace, multiple target tracking, navigation and remote sensing and other fields have a wide application prospect, for the promotion of the robot to the intelligent, autonomous development has a very important role.

Intelligent sensor and microprocessor combined, using computer software programming advantages, realize information processing of measurement data mainly includes the following two aspects: the calculation of nonlinear correction, compensation, calibration using software, and improve the precision of the sensor, repeatability. Signal filtering software, such as the fast Fu Liye transform, short-time Fu Liye transform, wavelet technology, simplify the hardware, improve the signal to noise ratio, improve the dynamic characteristics of sensor. Application of artificial intelligence, neural network, fuzzy theory, so that the sensor has higher intelligent analysis, judgment, self learning functions.

Calman filter for low level redundant real-time dynamic integration of multiple sensor data, the method using the statistical characteristics of the measurement model of recursive optimal decision fusion data in statistical estimation. Calman filter for the multi-sensor information fusion field comprises: using image sequence of target recognition, target tracking, robot navigation, inertial navigation, remote sensing etc.. Any of a sensor node failure does not cause the system failure, so the failure of the decentralized sensing structure of sensor and information processing unit has strong robustness and fault tolerance, as is shown by equation 5 [10].

$$\frac{dp_0(t)}{dt} = -\lambda p_0(t) + u\left(1 - p_0(t)\right) \qquad (5)$$

The representation of ontology has a variety of: a simple representation represents only a concept, has expressed the concept and attributes of the framework and semantic network, and can express richer semantic logic representation. The ER model and the UML class diagram can also be considered a body expression. But generally speaking, these ontology representations basically belong to the two classes: the expression of non - logic and ontology. From the concept of the classification, non logical expression is convenient but reasoning must be

implemented by the users themselves, logical expression can be clearly described by the predicate calculus.

The detection principle of the new, through the micro mechanical precision machining process design model, which can reflect the complete information of the measured object, one of the important technical approaches which is intelligent sensor. For example, a vibration sensor is to use this way to realize the intelligent sensor [11]. In vibration engineering is usually comprehensive effect of multiple modes of vibration, commonly used analytical method of vibration spectrum analysis. Because the sensor is at different frequency sensitivity and it is bound to cause the distortion analysis. The micro mechanical processing technology, can make extremely fine groove, groove, hole, film, cantilever beam, resonant cavity on the silicon wafer, constitute the performance excellent micro vibration sensor.

Advanced based on the neural network fusion method with adaptive reconfiguration method is tolerant of a sensor failure system. Multiple sensor neural network integration has the following characteristics: with a unified and fusion based on internal knowledge representation, through learning methods can be fused sensor information network, related network parameters (such as the connection matrix, node offset vector), and the knowledge rules are converted into digital form, then to establish knowledge base. The use of external environment and it is easy to realize automatic knowledge acquisition and associative inference. The complicated relationship will be uncertain environment, through learning and reasoning, accurate signal fusion system could understand. Because the ability of neural network with large scale parallel processing of information, making the system information processing speed, as is shown by equation 6.

$$\phi(x) - \phi(a) = \phi'(\eta)(x - a) \qquad (6)$$

GLUE is a use of machine learning techniques, the semi-automatic creation of mapping system, in heterogeneous ontologies in ontology, the requirement of GLUE system looks like a concept classification. Although the developers have also talked about GLUE can be matched to solve a wider range of, even including the relationships and attributes, also involves a complex mapping (such as 1 for N and N on the 1 map), but GLUE is mainly devoted to mapping to solve the classification system concept of 1 to 1.

The measured temperature signals from the sensing element received non electric analog, to convert between microprocessor digital signal processing, more line link designers must consider the number of relevant components, temperature measuring device to fall, then the impact of product

reliability and volume reduction. So, because of various kinds of factors will cause large error in transmission detection system; and because the detection environment is complex, multiple measuring points, signal transmission distance and all kinds of disturbances, the system will detect the stability and reliability of decline. Distributed optical fiber temperature measurement system for detecting principle of distributed optical fiber temperature measurement system is to measure optical parameters of optical fiber transmission using optical modulation and demodulation, detection of the optical signal modulation, which was a scheme to be measured.

Virtual instrument is a computer as the core hardware platform, by a computer instrument system design; user defined with virtual front panel, the test function is implemented by software. The basic idea is that in a test or instrument design with software instead of hardware as far as possible, namely "software is instrument". In short, the VI system is composed of computer, application software and hardware [12]. The user can through a friendly graphical interface (here called the virtual front panel) to operate a computer, a single traditional instruments like the same operation function, as is shown by equation7.

$$(\gamma g)_* := \bigvee \left\{ \zeta \in \underline{\mathbf{B}}\,(G, M, I) \middle| \zeta < \gamma g \right\}, \qquad (7)$$

In order to distribution can accurately reflect the temperature of space, and 8 points on the measured environment temperature collection. Each point temperature acquisition is composed of DS18B20 and single chip microcomputer. 8 bits microprocessor AT89S51 chip with low power, high performance CMOS KB structure of 4 Flashes erasable read-only memory and its interior is equipped with 4 K in addition to FLASH, also has 128 bytes of RAM, 2 16 timers / counter.

Ontology building label and Web documentation tags. XOL appeared in 1999, is a kind of can only express concepts, taxonomy and two parts between languages, and does not contain any reasoning mechanism. XOL is mainly designed for the biology domain ontology exchange. OML is based on the concept of a graph (conceptual graphs) and description logic language, can be used to express a concept, taxonomic relations and based on first order predicate reasoning.

Smart sensor is a micro processor, sensor with information detection, information processing, information memory, logical thinking and judging function [13]. To determine the primary factor in whether the sensor intelligent is its accuracy, at the same time, it should also have good reliability and stability. The sensor can be digital filtering processing, filter out useless data, and resolution in multiple parameters on specific parameter measurement.

4. Development of Smart Sensors System Based on Formal Concept Analysis and Ontology Model

The smart sensor consists of sensors, microprocessors and related circuit. Conversion of physical quantity sensor will be tested into a corresponding electrical signal, to signal conditioning circuit, filter wave, amplifier, and analog-to-digital conversion, sent to the micro computer [14]. The computer is the core of intelligent sensor; it is not only computing, storage, data processing of sensor data, but also through the feedback loop to adjust the sensor. Because the computer give full play to various software functions can complete the hardware to complete the task, thereby greatly reducing the sensor manufacturing difficulty, improve the performance of the sensor, reduce costs.

The system software is programmed by C++ language, use Keil C to debug. NRF2401 has 4 kinds of working mode, namely the transceiver mode, configuration mode, idle mode and power-down mode. The model is composed of PWR_UP, CE and CS three pins, as shown in Table 4 work modes are given in the 1 nRF2401 chip. The transmit power, nRF2401 chip operating frequency of all the work and all through the software settings completed. Can the 540 configuration bits for the initial TM configuration to nRF2401 through the DATCLK1 serial input before the system work. NRF2401 has 2 kinds of communication mode: Shock Burst and DirTM [15]. The work can be automatically in Shock Burst mode, nRF2401 data, CRC and so on, to the external programming work less, and make the nRF2401 on-chip FIFO.

GLUE uses a disposable method in determining similarity between classification trees. This means that no user intervention in this matching process. Users can only use the output matching process as a result of the foundation of ontology mapping. In other words, GLUE performs a mapping process "for similarity" this step, but repeat this procedure does not provide support. The applicability of the GLUE application case: provide assistance in creating ontology mapping, this means that the GLUE's job is to enable users to more easily find two based on the similarity of concept instances in the ontology, as is shown by equation 8.

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a} \qquad (8)$$

Formal concept analysis should first start from the construction of formal context, formal context gives a formal description of a domain knowledge, reflects the relationship between objects, attributes and their. If the said object set, B attribute set with A, R can express the relationship between objects and attributes, three byte A, B, R called a formal context.

Smart sensor consists of sensor, A/D converter, a signal processor, memory (or register) and interface circuit. Some products with multi channel selector, the central controller (CPU), random access memory (RAM) and read-only memory (ROM). Characteristics of intelligent sensor can output measurement data and related control quantity, adapting various micro controller (MCU); and it is to realize test function through software on the basis of the hardware, the development level of its intelligence depends on software [16].

Smart sensor has the following advantages: (1) compensation function: the nonlinear error, temperature change and the signal detection in the process of zero drift and sensitivity drift, the response time delay, noise and cross induction effect compensation function; the self-diagnosis function: switch on the power system self-check, realize operation of self when the system works, self diagnosis system failure, determine the location and fault; (2) self-tuning function: setting and checking system parameters, automatic range test of the conversion, the measured parameters of the automatic operation; the automatic data storage, analysis, processing and transmission.

Application of software MPLAB 8.33 programming environment, it is using C language to program in programming, modular design. The software part mainly includes: (1) the main program; (2) USART communication subroutine; (3) the AD sample program; (4) the interrupt subprogram module program. Part of the program code is as follows.

(1) IF inf(L) = (ϕ, ϕ) THEN；

(2) IF f*({x*})⊄Intent(inf(L)) THEN
  IF Extent(inf(L))=Φ THEN
    Intent(inf(L)):=Intent(inf(L))∪f*({x*})

(3) W=upperchild(upper) ∩lowfather(low);

(4) Rel(*C*)← *α** Relatt(*C*)+ *β** Relobj(*C*)；

(5) Int := Intent(C)∩ f({x*}))；

(6) if Rel(g1，g2)< Rel(C) then

(7) Rel(g1，g2) ← Rel(C);

(8) FOR nolayer[j++]∈ nolayer

(9) **For** *m*←1 **to** Length(*CA*)/*objnum*;

(10) Cn:= (Extent(C)∪{x*}, int);

The main design idea of the system is used to construct the FCA, combined with the show. The use of the popular, powerful programming language VCS 2005, with reference to the currently popular ontology building tool Protégé-2000 for classes, attributes and attribute values naming method for ontology engineer, bulk operations, to achieve a variety of functions of smart sensors system. Smart sensors communication way is through the RS-485 interface, using Modbus protocol, data communication mode using RTU model. Modbus RTU protocol defines the architecture, command message data, as is shown by Fig. 3.

The paper proposes development of smart sensors system based on formal concept analysis and ontology model. The overall microprocessor smart

sensor hardware part is constituted by: the PIC16F657 microcontroller, 31.0592MHz crystal, 3 TLP221 five DIP switches and the corresponding circuit. Selected core microcontroller PIC16F687 has the following advantages: 2348 words FLASH program memory, 258 bytes of data memory (SRAM) 256 bytes of EEPROM data memory, 11 interrupt sources 8-level deep hardware stack, internal watchdog timer, low-power power-saving sleep mode, with three external timer module, two 26-bit capture / 16/10 of the comparator PWM module, 54-bit to 24-Channel A/D conversion device.
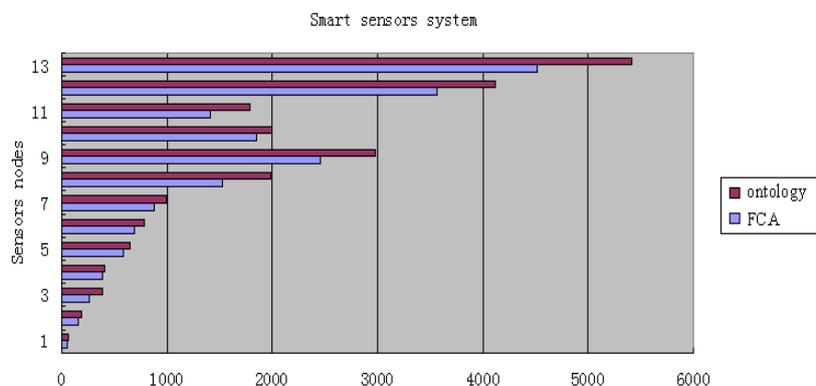

Fig. 3. Comparison results of development smart sensors system based on formal concept analysis with ontology.

Smart sensor technology innovation is reflected in: RS-385 bus and Address Number adjustable advantage to achieve centralized control station transceiver, on-site alignment clear, with a strong practical application. Go on-site installation, commissioning draw: 20-100ms response time can ensure reliable communication rate, plus relay communication distance up to 5000m, power consumption 0.1W, and bus work stable and at the same time into the 30 node. Long test run showed that stable, communications, the data interactive real-time, low power consumption, anti-interference ability and has a wide range of versatility, can meet the on-site applications for real-time and reliability requirements.

6. Conclusions

The smart sensor is the product of the combination of one or more sensitive components, precision analog circuits, digital circuits, microprocessor (MCU), communication interface, intelligent software systems and hardware integration in a packaging component. Type of sensor with data acquisition is data processing, data storage, self-diagnosis, self-compensation, calibration, logic, two-way communication, digital output / analog output function, which greatly improves the accuracy of the sensor, stability and reliability. The formal concept analysis technology into the construction of ontology, can help to get some abstract concepts and relations between concepts from the field, and the representation of ontology in the concept lattice, with lattice to represent concepts compared tree is easier to understand and can be used to construct the intelligent sensor system, can improve the effect of the intelligent sensor.

References

[1]. Cole R., Eklund P. W., Scalability in formal concept analysis, *Computational Intelligence*, 15, 1, 1999.

[2]. Godin R., Mili H., Mineau G. W., et al., Design of class hierarchies based on concept (Galois) lattices. *Theory and Application of Object Systems*, 4, 2, pp. 117-134.

[3]. Dan Dan Cui, Cai Qian Zhang, The Novel Model of Fusion Temperature Error Compensation System by Neural Network and Smart Sensors, *JCIT*, Vol. 8, No. 5, 2013, pp. 379-387.

[4]. Jing Zhang, The Application of CMOS Image Sensor and ZigBee in Building Smart Home Solutions, *JCIT*, Vol. 8, No. 5, 2013, pp. 444-453.

[5]. Pasquier N, Bastide Y, Taouil R, Lakhal L. Closed set based discovery of small covers for association rules, in *Proceedings of the BDA Conf*erence, 1999, pp. 361-381.

[6]. Berners-Lee T, James Hendler, Ora Lassila, The Semantic Web, *Scientific American*, 5, 2001.

[7]. Zhao FangFang, The Study on Key Feature Extraction for Sensor Fault Signal, *AISS*, Vol. 5, No. 7, 2013, pp. 1044-1051.

[8]. Ganter B, Wille R. Formal Concept Analysis: Mathematical Foundations, *Springer Verlag*, Berlin, 1999.

[9]. Juan M. Cigarran, Julio Gonzalo, Anselmo Peñas, et al., Browsing Search Results via Formal Concept Analysis: Automatic Selection of Attributes, in *Proceedings of the 2nd International Conference on Formal Concept Analysis (ICFCA'04)*, Sydney, Australia, February 23-26, 2004, pp. 74-87.

[10]. Maedche A, Staab S., Ontology Learning for the Semantic Web, *Special Issue on the Semantic Web, IEEE Intelligent System*, 2001, 16, 2, pp. 72-79.

[11]. Rubin D. L., Hewett M., Oliver D. E., et al., Automating Data Acquisition into Ontologies from Pharmacogenetics Relational Data Sources Using

Declarative Object Definitions and XML, in *Proceedings of the Pacific Symposium on Biology*, Lihue, Hawaii, 2002, pp. 88-99.

[12]. Missikoff M., Navigli R., Velardi P., Integrated Approach for Web Ontology Learning and Engineering, *IEEE Computer*, 35, 11, 2002, pp. 60-63.

[13]. Fuzhong Wang, Fukai Zhang, Linear Motor Positioning System Based On Acceleration Sensor, *JDCTA*, Vol. 7, No. 7, 2013, pp. 868-878.

[14]. Tan Li, Yang Minghua, Yu Chongchong, Li Xuanya, Cheng Bin, A Coverage Gap Filling Algorithm in Hybrid Sensor Network, *IJACT*, Vol. 4, No. 4, 2012, pp. 192-198.

[15]. Ye Hong, Yang Zhan-Ping, Li Jun, Li Shi-Ling, A Survey of Filtering Theory Based Multi-sensor Registration Algorithm, *IJACT*, Vol. 4, No. 5, 2012, pp. 318-328.

[16]. Jian Zhu, Hongbing Cao, Haitao Liu, Parking Space Detection Based on Information from Images and Magnetic Sensors, *AISS*, Vol. 4, No. 5, 2012, pp. 208-216.

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