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# WORKSTATIONS FOR ARTIFICIAL INTELLIGENCE AND ADVANCED CONTROL

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## 1. FOREWORD

In the process control and FA (factory automation) fields, the demand for productivity and quality is becoming more sophisticated and the automation area is expanding. Therefore, the expectations and demands for instrumentation and control systems are increasing qualitively and quantatively. In the robot, automobile, aircraft, and other mechatronics applied field, the pursuit of advanced functions and high performance is accompanied by a gradual increase in the role of contorl. Here also, expansion of the range of applications of control technology and sophistication of the demand for it are advancing. In these circumstances, Fuji Electric have applied advanced control, including the application of AI and fuzzy logic. Upon the farther advance of this, the importance of computer-aided design in control systems by which various analyses, simulations, and other design work and work for building a control system are performed easily and efficiently is increasing.

On the other hand, recent improvement of workstation (WS) capabilities has been amazing and large scale numerical computation and simulation which could not be performed in the past without a general purpose computer and super mini computer can be performed by WS. Moreover, it is rapidly becoming popular because of its small size and low price features and the need for distributed processing.

The system with "softwave package for total control system design" unifying and encompassing expert control and conventional control based on numerical models installed in the WS and the "workstation for AI and advanced control (AWS)" developed from such a background are outlined here.

## 2. APPLICATION FIELDS AND USE

The main application fields and use of the AWS are shown in *Table 1.*

*Table 1* Application fields and use

| Class | Application objective/field | Use |
|---|---|---|
| Process control | Steel, chemical, cement, paper pulp, electric power, water and sewage works, gas, petroleum, etc. | Adjustment work, control design work support, data analysis, control rules and knowledge base building |
| FA system | Foodstuffs industry, coil yard, automobile plant, wholesale market, formula feed plant, automatic warehouse, conveying system, etc. | Material handling system (facility, operating system) design support, material handling plan |
| Mechatronics equipment control | Robot, automobile, aircraft, prime mover, motor, generator, crane, servo device, etc. | Control system design work assistance, control system analysis, stability analysis, transmission analysis, feedback to control objective itself |
| Education | College, research laboratory, general education organization, industry | Control theory, control system design technology, expert system construction technology, fuzzy control technology education and training |

In the process control and FA fields, it is connected on-line with an MICREX distributed control system and A series minicomputer and incorporated into the control system. Modeling is performed based on the on-line data and an optimum control and expert control system is built and the data for control execution is downloaded to the controller and computer. Therefore, a control system capable of coping flexibly with plant changes and modifications can be built.

In the mechatronics applied field, it is mainly used as stand-alone system. A model of the control objective is represented by state equation and block line diagram and analysis, simulation, and evaluation are performed.

In the past, of the actual analysis, simulation, adjustment, and other work, those which are difficult to perform by other than a specialist are performed easily, including the education effect, even without a specialist. In the age in which software and control technology specialists are insufficient, the meaning and effect of this is large.

## 3. FUNCTIONS AND FEATURES

### 3.1 Abundant functions and actual results

As shown in *Table 2*, a wide range of functions based

*Table 2* AWS main function

| Function | Item | Method or form |
|---|---|---|
| Data analysis | Data transform | Linear, normalize, trend, filtering |
| | Statistial analysis | Histgrum, multiple regression analysis, principal component analysis |
| | Time series analysis | Correlation function, power spectrum, frequency response |
| | Identification | Auto-regressive model, approximated transfer function |
| | Prediction model | Kalman filter, GMDH |
| Control system design | Optimal control | PID auto tuning, optimal regurator |
| | Adaptive control | Gain scheduling of two direction |
| | Decoupling control | Inverse Nyquist array method |
| | Time delay system | Smith method, process model method |
| | Frequency response analysis | Bode diagram, Nyquist diagram, phase margin, gain margin |
| | Root rocus | S-plane, Z-plane |
| | Transient response simulation | Block diagram, transfer function, state equation |
| Expert system | Knowledge base | Production rule, criteria frame, network, numerical expression |
| | Test | Static check |
| | Simulation | Dynamic simulation (time series data) |
| Fuzzy control | Control rule | Fuzzy production rule, membership function |
| | Optimize | Optimal fuzzy variable, optimal function |
| | Simulation | Static and dynamic simulation |
| Utility | Data base | Time series data, model, knowledge base |
| | Graphics (plot) | 2-D, 3-D, scattering, etc. |
| | Data transmission | TCP/IP, TTY |

on classic control theory, modern control theory, AI, etc. is available. The software which embodies these functions is based on packages with actual results created during the offering of many instrumentation and control systems by Fuji Electric.

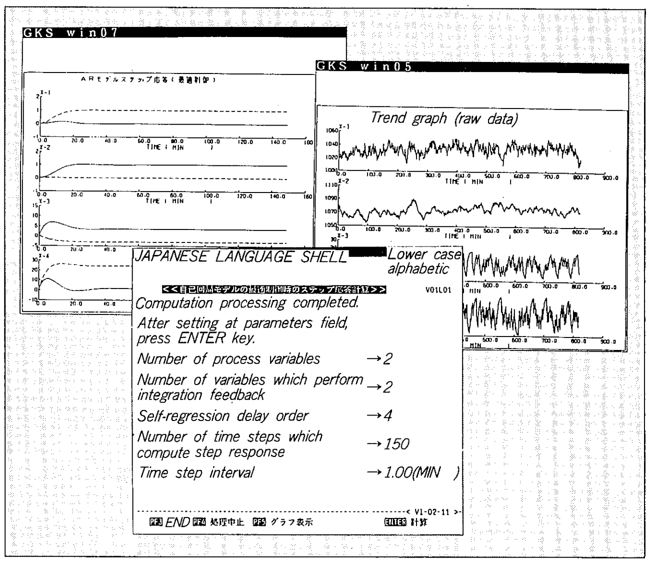
### 3.2 Unification of AI and control logic

Design of an AI and optimum control harmonized system is possible by performing control system design based on AI and control theory in the same environment. Further, not only subjective knowledge obtained from intuition and experimence with AI and fuzzy control, but also quantative and objective knowledge (so-called "deep knowledge") can be taken in by statistical analysis and modeling.

### 3.3 On-line data processing

By network connection with an instrumentation system and computer system, the on-line data can be analyzed and various computation and simulation can be performed and, as a result, the obtained control rules and control parameters can be transferred to the execution system.

*Fig. 1* Examples of panel for optimum control design




### 3.4 Conversation type input/output

Analysis and design can be performed easily by conversation type Japanese language menu system using multiwindow. Output of messages and computed results (numerics) from the program and input of data and conditions setting from the user are performed simultaneously at a blank field description type panel. Moreover, operability is improved by process selection, by function keys.

### 3.5 Graph output

Since the result is displayed in color by a graph, it can be evaluated at a glance and repetitive analysis is easy. Besides being displayed on the displays, the graph is also printed out to a laser beam printer and X-Y plotter. An example of a conversation type input/output and graph display multi-window screen in shown in *Fig. 1.*

## 4. SYSTEM CONFIGURATION

### 4.1 Hardware configuration

The hardware is based on the UNIX workstation Σ station 230. Its specifications are shown in *Table 3.* Its exterior view is shown in *Fig. 2.*

### 4.2 Software configuration

The software configuration is shown in *Fig. 3.* The software for building and designing AI and advanced control is packaged by function. The packages can be installed selectively as required as an option. Packages can also be added gradually.

Operating system of AWS is SX/A, which is based on UNIX* system V (Rel 3.0) incorporating the functions of the Berkeley version and capable of real-time processing. Therefore, it is also possibe to use as a user software

*Fig. 2* Exterior view of AWS

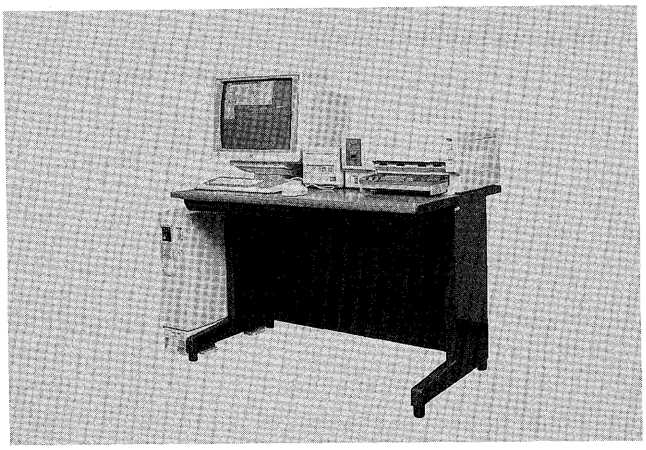


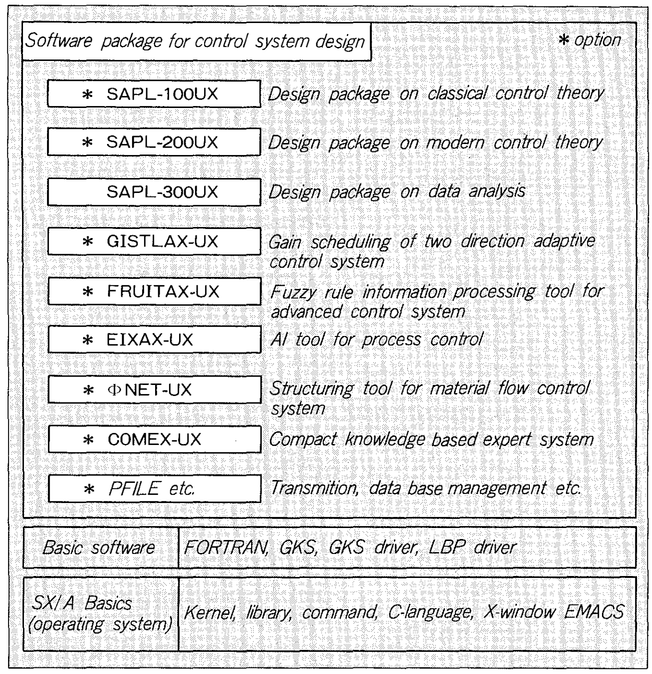
*Table 3* AWS hardware specifications

| | | |
|---|---|---|
| CPU | Processor | 68030 (25MHz) |
| | Floating point operation | 68882 (25MHz) |
| Memory | 4MB ~ 32MB | |
| Magnetic disk | 134MB or 330MB (expandable) | |
| Floppy disk | 1MB (5 inch) | |
| Cartridge MT | 120MB (option) | |
| Display | 20/16 inch color (256 colors), 1280 x 1024 dots or 19 inch monochrome 1280 x 1280 dots | |
| Keyboard | JIS arrangement | |
| Mouse | 3 buttons | |
| External interface | RS-232C (standard) | |
| | Ethernet® (standard) | |
| | Centronics (standard) | |
| | GP-IB (option) | |
| Output devices (option) | Laser beam printer A4/B4 240DPI | |
| | X-Y plotter A3 | |
| | Japanese language printer | |

® : Ethernet is a registered trademark of Fuji Zerox.

*The UNIX operating system was developed by AT&T Bell Laboratories and is licensed from AT&T.

*Fig. 3* Structure of AWS software




development machine.

## 5. CONCLUSION

The AWS introduced here was developed for control system analysis and design. Various software with a actual record of use are integrated and the man-machine interface is enhanced and installed to a WS. The range of applications of AI and advanced control is extended to more fields and a greater effect is obtained by extending the use of tools which were for specialists in the past to general technicians.