

SYSTEM FOR EVALUATING SKILLS OF TO-BE-EXAMINED PERSON

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a system and method for evaluating the technical ability of a to-be-examined person and more particularly relates to a system and method for determining and evaluating the abilities of a to-be-examined person to design a technical system and to construct an actual apparatus using a computer.

Description of the Prior Art

Recently, in various technical fields, private and public organizations have sponsored ability examinations and have given various forms of recognition to people who have proven abilities and, for example, they have given certain qualifications to people who passed such examinations. In this regard, individuals who have certain qualifications, such as the qualification of an Information Processing engineer, have advantages in finding employment over persons having no such qualification. Therefore, it is deemed that these kinds of ability examination systems will be increasingly conducted in more technical fields, in the future.

In reality, there is no system for objectively examining and evaluating the ability of a person who is involved in the design of, for example, an automatic manufacturing line for manufacturing products, or various types of automatic apparatuses for use in such lines, as well as the construction of such automatic apparatuses having desired performance on the basis of the design. A person responsible for such tasks will be hereinafter

referred to as "an automation engineer". The reason why no such system exists will be described later.

An automatic apparatus is generally defined herein as an apparatus which autonomously performs target operations on the basis of certain programs (software). A more detailed description of such an automatic apparatus will be given later during the detailed description of the preferred embodiments of the invention.

The history of automation technologies can be classified into first to fourth generation systems, wherein the fourth generation is a generation which is expected to grow. Technical evaluations which form the substance of the present invention are based on the technologies of the respective generations and, therefore, the automation technologies of the respective generations will be described hereinafter.

Automation technologies can be conceptually represented as follows.

Referring to Fig. 4, an automatic apparatus is shown for causing an apparatus element/tool T to perform desired operations on an object/work W, such as a mechanical member. For example, this may comprise moving the work W to a predetermined position. To achieve this there is provided a tool driving/controlling portion 50 consisting of a mechanism M that causes the tool T to perform predetermined operations. An actuator A provides a driving force to the mechanism M. A controller C controls the operation of the actuator A, and a sensor S provides predetermined information to the controller C through feedback control.

In a first generation system, the mechanism M is configured to be of a non-uniform-conversion type Mb

constituted by hinges and slides or the like. The actuator A for driving the mechanism M, which is of the non-uniform-conversion type Mb, is of a constant-velocity type Aa. These types of mechanisms M may be selected from motors which rotate at constant speeds or cylinders having piston rod which move linearly. Accordingly, the controller C for controlling the actuator A, of the constant-velocity type Aa, is of an ON/OFF type Ca. The sensor S is also of an ON/OFF type Sa capable of acquiring information about the operation of the mechanism M (indicated by the number 51), being of the non-uniform-conversion type Mb.

Namely, in the first generation system, the operation of the actuator A, which performs simple constant-velocity operations Aa, is converted into operations of the mechanism M; such as a velocity reduction at a stroke end through a crank mechanism, a rapid return through a lever-slider mechanism; and/or a prevention of return through a toggle mechanism, and the like to realize an ingenuity of the mechanism M. The present inventors describe the first generation as "a generation of circles and straight lines" as stated, in many technical books and the like. Namely, the mechanism M, the actuator A, the controller C and the sensor S (hereinafter, referred to as "M·A·C·S") in the tool driving/controlling portion 50 are configured as "(the non-uniform conversion type Mb)·(the constant-velocity type Aa)·(the ON/OFF type Ca)·(the ON/OFF type Sa). Namely, the M·A·C·S is configured as Mb·Aa·Ca·Sa.

The first-generation technology has not been discarded at the transition of the technology from the first generation to the second generation. The first generation technology is still very usable now, and can

be applied to second generation systems and the subsequent generation systems which will be described later, to increase the ingenuity of the apparatus. The configuration of the aforementioned mechanism Mb is a factor which significantly affects the ingenuity of the entire automatic apparatus of any of the generations including the first generation.

When fabrication of cams was made easier with the development of machining tools, second generation systems developed came. In the second generation systems, the ingenuity of the non-uniform conversion Mb of the mechanism M was improved by configuring the cam with high accuracy and complicity. Although the M·A·C·S of the second generation is Mb·Aa·Ca·Sa as in the first generation, the non-uniform-conversion Mb achievable by a cam when used as the mechanism M had significantly-improved ingenuity. Namely, it can be said that the second generation is "a generation of mechanical cams".

It was evident that dedicated mechanical cams must be configured for respective operations of the tool T. However, with advancing manufacturing of a wide variety of products in small quantities due to variations of markets, it had become more difficult to cope with such variety by the method of fabricating respective mechanical cams with the machining tools. Namely, it can be said that the third generation is "a generation in which the second-generation mechanical cam was changed to an information cam".

Namely, there was a need for a method which enables fabricating the cam with enhanced softness and the third generation realized that.

From a viewpoint of the functions of the second-generation cam, the cam had two functions, namely "the

function of transferring forces", and "the function of possessing information about position/time". This enabled transferring the driving force of the actuator A through the mechanical cam M to cause the tool T to perform predetermined operations.

On the contrary, the information cam of the third generation was configured only to possess information while "the transfer of forces" was implemented through a servo.

Thus, an information cam configured only to possess information is realized in the following aspects.

- (a) "template cam" like a cut-out paper pattern
- (b) "picture cam" which is simply a drawn picture
- (c) "software cam" stored in a memory of a computer

Particularly, in the case of a software cam, when the product item is to be changed over, it is possible to achieve changeover of the cam (changeover of the cam curve) within an extremely short time by operating the computer through key-board inputting or through item-changeover signals from the outside, thus enabling largely enhancing the flexibility of the automatic apparatus.

Consequently, in the third generation, the mechanism M is mainly of a uniform-conversion type Ma, the actuator A is of a variable-velocity type Ab such as a servomotor, the controller C is of a numerical-quantity type Cb (for controlling the actuator A of the variable-velocity type Ab), and the sensor S is of a measurement type Sb, which outputs information of measurement values for ensuring the controlled operation of the controller C (of the measurement type Cb). The measurement information is, for example, operation information 52 about the actuator

A of the variable-velocity type Ab. In this regard, the M·A·C·S of the third generation is Ma·Ab·Cb·Sb.

As described above, the performance of automatic apparatuses has improved in terms of ingenuity and flexibility and the like, with the transitions from the first to the third generations. However, there were problems common to these three generations. That is, apparatuses of any of these generations can perform proper operations on the precondition that the condition of the to-be-operated work W and tool T is maintained constant (hereinafter, referred to as "work side consistency").

For example, when the work side consistency is maintained, such as when all of the to-be-operated works W have an identical shape and are placed at the same position, the aforementioned apparatuses of the respective generations can repeatedly perform ingenious operations at high speeds.

However, in the event of the occurrence of changes of the condition of the works W, such as deviation of the position at which the works W are placed, partial differences of the shapes of the individual works W and stop of feeding of the works W to the tool T, namely in the event of impairment of the work side consistency, malfunctions will occur as follows. For example, the works W can not be properly handled with predetermined operations of the tool T, the works W can not be handled at all, or the predetermined operations are repeatedly performed even though there exists no work W. These problems may be caused by changes of the condition of the tool T such as wear of the tool T, as well as by changes of the works W.

Namely, the automatic apparatuses of the first to third generations are identical in the respect that they repeatedly perform the same operations for the same type of works. Even though the third-generation apparatus employing an information cam has significantly-improved flexibility in the respect that the cam can be rapidly changed, the respective cams are associated with the operations of the tool T with one-to-one relationship. Also the third-generation apparatus operates relying on the work side consistency, similarly to the first and second generations.

In view of the aforementioned facts, the forth-generation apparatus forms a tool driving/controlling portion 50 configured to check the condition of the work W, detect the operating condition of the tool T which handles the work W, and properly set and control the operation of the tool T in accordance with the condition of the work W and tool T.

Namely, as indicated by the numbers 53 and 54, the tool operating/controlling portion 50 is configured such that the sensor S directly acquires information about the work W and/or the tool T from the work W or the tool T and, on the basis of the information, the tool T is caused to perform proper operations in accordance with the conditions of the work W or the tool T. The forth-generation apparatus is configured by incorporating algorithms for determining the amount of movement of the tool T, and/or the direction of driving of the tool T and the like, in accordance with the condition of the work W or the tool T. These algorithms are incorporated into the controller C of the tool driving/controlling portion 50 in order to enable ingenious control of the actuator A

for properly controlling the operation of the tool T anytime.

Accordingly, the tool driving/controlling portion 50 is structured such that the mechanism M is of a uniform-conversion type Ma, the actuator A is of a variable-velocity type Ab such as a servo motor, the controller C is of a numerical-quantity type Cb, the sensor S is of a measurement type Sb, similarly to that of the third generation, wherein the setting for detection of the condition of the work W (the arrow 53) and/or the setting for detection of the condition of the tool T (the arrow 54) are utilized to make feedback signals. Further, the operation information 51 and 52 of the mechanism M and the actuator A is also utilized as required.

The automation technologies have been successively advanced from the first generation to the forth generation as described above. With advancing technologies, the number of automation engineers who deal with these technologies has also increased and such automation engineers have also been required to have higher technical skills as the technology advances. Further, it is deemed that the needs for automation engineers will be further increased in the future, in order to reduce the need for labour, to manufacture a wide variety of products in small quantities, and to ensure consistency of products and the like, in a variety of business organizations. From this view point, business organizations which employ such skilled employees eagerly desire to know the actual grades of skills of people referred to as automation engineers. However, at the present time, there is no system for evaluating the skills of automation engineers and for giving certain qualifications to the tasks performed.

This is typically due to the following reasons.

For example, in the case of information processing engineers for whom there exist ability evaluation systems, the subjects of evaluations are substantially limited to software, such as software development and processing of software in essence. On the contrary, in the case of automatic apparatuses, the mechanisms constituting the apparatus and the software for operating the mechanisms are associated with each other in a complicated manner. Furthermore, there are various types of skills of automation engineers such as the ability to design an apparatus, the ability to construct an actual apparatus, the abilities for testing the performance of the constructed actual apparatus and to modify and repair it on the basis of the result of test. Therefore, there are a great number of determination factors for evaluating the skills of automation engineers, and the evaluations are complicated. Consequently, in order to assess each skill it would be necessary to process an enormous amount of information and thus, the areas/subjects of evaluations/assessment must be limited in advance, particularly when in the case of manually conducting such evaluations. Further, since proper evaluations have been impossible at the present time for various reasons, such as the difficulty of eliminating arbitrariness in evaluations, it has been considered that, due to the variety at skills, it is actually impossible to evaluate the skills of automation engineers objectively and fairly even though there has been strong needs therefore.

Also, in the case of evaluating an automation engineer's skills in constructing a mechanism or the like, or evaluating their skills in developing software

for operating a mechanism, it is necessary to select and set questions suitable for such evaluations. Further, in the case of evaluating the ability of an individual to construct an actual apparatus on the basis of the performance of the constructed actual apparatus, it is necessary to process and evaluate various types of items. For example, it is necessary to process measured performance data about the actual apparatus. This will require an automated processing system employing a computer. However, there has not existed such a system at all prior to the present invention.

Namely, automation engineers are required to have various types of abilities as follows.

(1) the ability to select and design mechanisms constituted by selecting from a great number of combinations of hinges and slides

(2) the ability to design mechanical cams for realizing various types of operation characteristics

(3) the ability to design means for driving an electrical actuator such as an alternating-current motor, a direct-current motor, a solenoid and many others

(4) the ability to design means for driving a fluid actuator such as an air cylinder, a rotary actuator and many others

(5) the ability to design means for driving a pulse driven actuator such as a servo motor, a stepping motor and the like

(6) the abilities to select various types of sensors such as photoelectric sensors, magnetic sensors and the like, select the portions for detections and select signal functions

(7) the ability to program the setting of input and output of the control by a programmable sequence controller

(8) the ability to set the input and output of control by a computer and to program therefor

(9) the ability to set and design an input/output interface circuit along with the aforementioned (7) and (8)

The aforementioned items (1) to (9) are items which respectively relate to specialized fields of expertise and, in particular, some of the items are treated as independent education subjects in universities and professional schools which teach technical subjects.

The aforementioned items (1) to (9) are all means for attaining objects and automation engineers are required to have the abilities to select/set or design optimum items from the respective items and combine them. However, in practice, engineers who have considerable knowledge in some or all areas do not necessarily have excellent ability to construct an overall system according to the object.

As discussed above, it is likely that it is impossible to determine the actual ability to construct systems with the method of "determining the ability on the basis of means". Such a method determines the technical abilities of a subject individually for the aforementioned respective means, since the method involves an extremely large number of determination factors, this makes the description of evaluations significantly complicated and also difficult to evaluate the ability to combine optimum selections for objects.

The present invention is characterized in that the evaluation is basically structured by "designation of

target operation characteristics" for the to-be-examined person and "verification of the target attainment level" on the basis of the apparatus constructed by the person. In order to determine on the basis of the target, significantly complicated determination factors are processed by a computer in order to determine the overall technical ability of the to-be-examined person easily and accurately and also for enabling objective determinations.

Further, it has been known to remove the controller C from the constituent elements of the aforementioned automated apparatus and to conduct evaluation of the controller C separately. That is, in the case of simple control using a programmable sequencer, a simple mechanism portion which operates with the sequencer is prepared and the technical ability to construct a program for driving the mechanism portion with the sequencer is evaluated and determined. As discussed above, this is significantly different from determining the overall skills of an automation engineer. In other words, only limited skills can be evaluated with such conventional methods which do not employ W. T. MACS overall automation evaluation systems with computers.

Although there exists no known prior-art technique similar to the present invention in terms of the technical field as previously described, the following Patent Documents are illustrative of typical prior art approaches to assessing technical skills of individuals. The following Patent Document 3 discloses a system in which designs are made using a computer and technical evaluations are conducted on the basis of the contents of the designs. However, this system merely determines and evaluates the content of designs made using the computer

and does not have the viewpoint of constructing an actual apparatus or machine on the basis of the designs and evaluating the performance of the apparatus or machine for comprehensively evaluating the technical ability of the to-be-examined person. This is considered to be naturally resulted from the fact that Patent Document 3 aims at evaluating the ability to effectively utilize predetermined "designing software", namely the ability for the utilization of the software. Consequently, "designing software" is different from designing an apparatus according to the present invention, which will be described later.

[Patent Document 1] JP-A No. 2002-024451

[Patent Document 2] JP-A No. 2002-132839

[Patent Document 3] JP-A No. 2004-110333

In automation techniques, it is most important to properly select elements from respective groups of elements. These groups may include: tools T which are moved in accordance with target operations for the work W; mechanisms M; actuators A; controllers C; and sensors S for realizing the movement of the tool T. It is also important to construct the apparatus comprising the selected element. A system for evaluating the skills of automation engineers is required to properly evaluate these aspects.

For these aspects, there are many items to be considered such as velocity characteristics and force characteristics, cycle time of movement, amount of movement, accuracies of movement and stoppage, characteristics changes due to the changes of the load and the friction coefficient, setting of interlock with respect to the operations of other mechanisms which cooperate therewith, and the setting of overlap of the

operation and the like. Proper evaluations must be consider such items.

In order to consider the aforementioned items, it is necessary to actually construct an apparatus using actual equipment, operate the apparatus and verify its operation and whether or not the accuracy of the actual apparatus matches the theoretical accuracy, as well as merely setting values on paper. Namely, there is a need for equipment for enabling construction of an actual apparatus for evaluating the skill (practical skill) of constructing an actual apparatus and a system for evaluating the performance of the actual apparatus constructed using the equipment. Also, it is necessary to incorporate such a practical-skill evaluation system into the skill evaluation system.

It is therefore desirable to provide a skill evaluation system using a computer which is directed at overcoming the aforementioned problems with traditional skill evaluation systems.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

SUMMARY OF THE INVENTION

According to a first aspect, the present invention provides a system for evaluating the skill of a to-be-examined person using a computing device, including a

computing portion having a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and a means for evaluating the skill of the to-be-examined person; and a group of elements for constructing said apparatus designed at the designing means of the computing portion; wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means, and a means for measuring operating characteristics of the apparatus, such that an ability of the to-be-examined person to design an apparatus and an ability of the to-be-examined person to construct the apparatus is evaluated.

According to a second aspect, the present invention provides a system for evaluating the skill of a to-be-examined person using a computing device, including: a computing portion having a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and a means for evaluating the skill of the to-be-examined person; and a group of elements for constructing said apparatus designed at the designing means of the computing portion; wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means, a means for measuring operating characteristics of the apparatus, and a means for evaluating modifications made by the to-be-examined person to the apparatus on the basis of the measured operating characteristics, such that an ability of the to-be-examined person to design an apparatus, an ability of the to-be-examined person to construct the apparatus, and an ability of the to-be-

examined person to make modifications to the apparatus is evaluated.

According to a third aspect, the present invention provides a system for evaluating the skill of a to-be-examined person using a computing device, including: a computing portion having: a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and a means for evaluating the skill of the to-be-examined person; and a group of elements for constructing said apparatus designed at the designing means of the computing portion; wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means on the basis of the elements selected by the to-be-examined person to achieve target operating characteristics of the apparatus and the adequacy of the combination of these elements; and a means for measuring operating characteristics of the apparatus to determine an attainment level of the measured operating characteristics of the apparatus against the target operating characteristics of the apparatus, such that an ability of the to-be-examined person to design an apparatus and an ability of the to-be-examined person to construct the apparatus is evaluated.

According to a fourth aspect, the present invention provides a method for evaluating the skill of a to-be-examined person including: presenting a problem to the to-be-examined person, said problem requiring the to-be-examined person to create an apparatus to perform a task; receiving a design of said apparatus from the to-be-examined person; evaluating the design; constructing said apparatus in accordance with the design; evaluating the

performance of the constructed apparatus; and determining an overall evaluation of the skill of the to-be examined person to design an apparatus and to construct the apparatus to solve the problem.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the general outline of an apparatus for executing the system according to the present invention;

Fig. 2 is a block diagram illustrating, in detail, the functions of the computing portion 1, out of the blocks illustrated in Fig. 1;

Fig. 3 is a flow diagram illustrating an exemplary executing condition of the system according to the present invention;

Fig. 4 is a block diagram conceptually illustrating the structure of the tool driving/controlling portion for controlling the movement of the tool;

Fig. 5 is a diagram illustrating a target displacement characteristic for a question and a displacement characteristic of an apparatus constructed by a to-be-examined person;

Fig. 6 is a view representing an exemplary design content displayed on a computer screen;

Fig. 7 is a view representing an exemplary list of usable members displayed on a computer screen; and

Fig. 8 is a view representing a state where a design content for another question is displayed on the computer screen.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments of the present invention will be described using the drawings.

Fig. 1 illustrates the general outline of the structure of an apparatus for realizing a system according to the present invention. This apparatus includes a computer as a computing portion 1 constituting the apparatus main body and an assembling apparatus 2 which enables assembling the content of design which is made by a to-be-examined person 3 at the computing portion 1.

First, the general outline of the flow of this system will be described with reference to Fig. 1. Here, Fig. 1 illustrates the structure of an apparatus for executing this system.

At first, a predetermined question is displayed for the to-be-examined person 3 on a display portion (designated by the reference character 12 in Fig. 2) such as a liquid crystal or a CRT of the computing portion 1 or through hard copying. Out of the usable elements for the aforementioned question such as the aforementioned mechanism M, the actuator A, the controller C, the sensor S, the interfaces, connecting members and the like, elements which can be displayed by graphics such as the mechanical module and the actuator are displayed on the display portion of the computing portion 1. More specifically, for example, types and lengths of the lever and the rod and lengths of the crank arm and the like are displayed for the mechanism M, and types of the actuator

such as an air cylinder and a stepping motor and the like, and the amount of strokes of the air cylinder and the like are displayed for the actuator A by images, graphics, specific numerical values for those having specific numerical values or settable ranges for those having variable numerical values.

Out of these elements, the to-be-examined person 3 selects, at a designing means 5, constituent elements displayed for the aforementioned question through an inputting means 4 such as a key board or a mouse, selects elements that he considers optimum, associates the respective elements with one another and further inputs numerical values to perform designing (a concrete example of the designing method will be described later in more detail). When the designing has been completed, design content data (data indicating the content of the design made by the to-be-examined person 3) made by the to-be-examined person 3 is evaluated by a processing portion 6 and the computing portion 1 executes an evaluation about the ability of the to-be-examined person 3 to conduct designing at first.

Next, the to-be-examined person 3 selects actual constituent elements corresponding to the constituent elements employed in his design made at the designing means 5 and actually assembles a mechanism based on his design at the assembling apparatus 2 (the reference numeral 7). Subsequently, the assembled mechanism is actually operated and the operating condition, the operation accuracy and the like are determined (the reference numeral 8) and the determined data is automatically output to a processing portion 6 of the computing portion 1. The processing portion 6 evaluates the ability of the to-be-examined person 3 to assemble an

actual apparatus on the basis of determination/evaluation data which has been made to be data in advance. Further, the processing portion 6 finally evaluates the skill of the to-be-examined person 3 from the evaluation data of the ability to design and the evaluation data of the ability to assemble the actual apparatus (the reference numeral 9).

At this time, there is also a method as follows. That is, the to-be-examined person 3 determines the performance of the actual apparatus designed by himself and, when the result of the determination reveals, for example, that the designed configuration can not provide a sufficient maximum speed, he modifies the design of the mechanism, assembles an actual apparatus again on the bases of the modified design and then performs determination until the target performance can be provided. In this case, the number of times the design has been modified to provide the target performance and the like is also employed as a criterion for the skill evaluation.

With reference to Fig. 2 and Fig. 3, the aforementioned structure will be described in more detail. Fig. 2 illustrates the structure of the apparatus for executing this system and Fig. 3 illustrates an exemplary condition where this system is being executed.

In a question data base 10 of the computing portion 1, questions for determining and evaluating the skill (ability) of the to-be-examined person 3 has been preset and prerecorded. These questions include, as data, direct questions such as "Construct a system for" and also include equipment for achieving the direct issues, operating conditions (accuracy) and the like.

A person who executes the skill evaluation of the to-be-examined person 3 selects a predetermined question through a question setting means 11 and the content of the selected question and the required constituent elements are displayed on a displaying means 12 (S1 and S2 of Fig. 3). The to-be-examined person 3 designs a mechanism for achieving the question displayed on the displaying means 12 and constructs an actual mechanism corresponding to the content of the design. In this case, the mechanism and the actuator and the like set for the question may be displayed, on the displaying means, either by text such as a "variably-structured mechanism module" or by graphics of elements constituting the module such as a flat cam, a lever, a slider and the like.

First, the to-be-examined person 3 constructs a mechanism for achieving the aforementioned question by the designing means 5 through the inputting means 4. At this time, in the case where the constituent elements of the mechanism are displayed by graphics on the displaying means, it is possible to make the design, for example, by dragging the respective constituent elements to predetermined positions on the displaying means 12 (this method will be described later in more detail using the drawings). Particularly, by configuring the system to graphically display the content of design from the beginning using as little language as possible, this system may be utilized all over the world without language barrier. Namely, the designing means used therein may have any structure which enables the to-be-examined person 3 to select predetermined elements for constructing a mechanism that he considers optimum for the given question enables him to set the combination of

the selected elements and also enables conversion of the content of design into objective data for evaluation. Accordingly, the "designing means" does not designate software for designing with narrow sense.

The to-be-examined person 3 selects optimum elements from the group of mechanisms M, the group of actuators A and the group of sensors S (S3, S4 and S5) which are displayed through the designing means 5. Further, in order to enable feedback control of the entire mechanism, he sets the ability of the sensor S selected for detection during the designing, through means 16 for setting and adjusting sensors. The aforementioned selection is performed as follows. That is, the to-be-examined person 3 selects elements from a mechanism data base 13a, an actuator data base 13b and a sensor data base 13c within a mechanism element data 13 through mechanism-element selecting means 14 and performs designing through the designing means 5 in accordance with, for example, the aforementioned method. In this case, the mechanism element data 13 is preset such that only mechanism elements corresponding to the set question can be prepared in aforementioned mechanism element data 13. However, it is also possible to set the mechanism element data 13 such that all constituent elements including other constituent elements than those corresponding to the question, instead of pre-limiting the selection range, to enable evaluating the ability of the to-be-examined person 3 to design under more strict conditions.

Further, in addition to these mechanism elements, the to-be-examined person 3 creates a predetermined controller program through means 15 for creating a

controller program for controlling the constructed mechanism. (S6).

With the aforementioned method, the to-be-examined person 3 performs designing for the predetermined question and the evaluation system grades and evaluates the content of design (S7). Namely, answers have been input to an answer data base 17 for respective questions stored in the question data base 10 and evaluation points are stored in an evaluation-point data base 18 in association with degrees of achievement of the questions.

A central processing device 19 evaluates the ability of the to-be-examined person 3 for designing from the point calculated at an evaluating means 20 on the basis of the design data made by the to-be-examined person 3 and the time taken to complete the design which is output from a clock 21. The processes for the evaluation of the ability of designing are all performed at the computing portion 1 which is a computer.

Then, when the to-be-examined person 3 has completed the designing, he actually constructs the mechanism on the basis of his design (S8). At this time, he selects the mechanism elements used in his design from a mechanism unit 22a, an actuator unit 22b and a sensor unit 22c through a mechanism element unit 22, then assembles an actual apparatus as shown on the assembling apparatus 2 and performs setting of the aforementioned controller.

On completing the construction of the actual apparatus, the to-be-examined person 3 terminates the operation and the time taken to complete the operation is output to the central processing device 19. Further, the data of operation of the actual apparatus (data of the accuracy, operation speed and the like) which has been

determined by the measurement means 24 is output to the evaluation-point data base 18 and the ability of constructing an actual apparatus is graded and evaluated through the evaluating means 20 in accordance with the same method as that for the ability of designing (S 9 and S10). Further, similarly to the case of the ability of designing, the clock 21 outputs the time required to complete the construction of the actual apparatus and the result of time measurement therefrom is also added to the evaluation of the ability of constructing an actual apparatus.

Finally, the central processing device 19 determines and evaluates the ability of the to-be-examined person 3 for automatic equipment, from the evaluations for the ability of designing and the ability of constructing the actual apparatus (the reference numeral 25 in Fig. 2).

Exemplary criteria for evaluation will be described as follows.

Namely, if there are differences between operation characteristics of the constructed actual apparatus and the target characteristics (question), the point of the to-be-examined person 3 will be detracted in accordance with the differences. Also, if the time taken to complete the construction of the actual apparatus is long, this may be utilized as an object of detraction of the point. This time is counted by the clock 21 of Fig. 21, for example.

For the evaluation and the determination of operation characteristics, for example, a frictional driving roller type potentiometer constituted by a friction disk mounted to the shaft of a potentiometer can be pressed against the output end such as a slide table (linearly moving table) surface to detect the output

operation characteristics, thus providing a graph of the displacement operation characteristic as in Fig. 5.

In the figure, L1 is a curve illustrating a target displacement characteristic and L2 is a curve illustrating an actual displacement generated by the operation of the apparatus constructed by the to-be-examined person 3. Obviously, as the curve L2 approaches the curve L1, the to-be-examined person 3 will get a higher point. Here, S_0 indicates a maximum target displacement and t_0 indicates the time taken to move S_0 . On the other hand, S_1 indicates a maximum displacement provided by the apparatus constructed by the to-be-examined person 3 and t_1 indicates the time required to move S_1 .

In view of the aforementioned curves L1 and L2, comparisons are made between the data at respective points on the diagrams L1 and the data at the respective points of the curve L2 and the following grading method is applied thereto. For example, if the maximum value S_1 of the operation of the apparatus constructed by the to-be-examined person 3 is different from the maximum value S_0 of the target curve L1 by 10 % thereof, 10 points will be detracted from a maximum point of 40 point and, if the average speed V_1 of the apparatus is different from the target average speed V_0 by minus 10 % thereof, 5 points will be detracted from the aforementioned maximum points.

Here, the target average speed V_0 and the average speed V_1 provided by the apparatus of the to-be-examined person 3 are defined as the following equations.

$$V_0 = S_0/t_0$$

$$V_1 = S_1/t_1$$

Further, there is another evaluating method as follows.

The procedure until the to-be-examined person 3 completes assembling of an actual apparatus is the same as that of the aforementioned example and, after detecting operation characteristics thereof, the structure and the design of the system are modified as previously described as required. Namely, the design and the structure of the actual apparatus are repeatedly modified and, when the target operation characteristics can be finally achieved, point detracting is performed on the basis of the time taken until then, the number of design-modified components and the number of modified program steps and the like. In this case, the desired characteristics can be finally realized, thereby providing the advantage that determination criteria can be established more easily than the degrading method employing operating characteristics comparisons. Namely, this evaluating means provides the advantage that the evaluation-point data base 18 of Fig. 2 can be structured more easily.

Further, it is necessary to incorporate many types of elements into the computing portion 1 of the four groups of elements for constructing automatic systems which are the group of mechanisms M, the group of actuators A, the group of controllers C and the group of sensors S and actually prepare the mechanism-element unit 22 such that these elements can be used for assembling respective mechanisms associated with various data to enable the to-be-examined person 3 to set and combine them over a wide range during constructing the mechanism by selecting constituent elements from a number of elements.

More specifically, it is desirable that the respective elements are prepared to have structures and

functions such that means having the following functions can be structured.

[1] Mechanisms

- (a) Velocity up/down means with the mechanism
- (b) End-velocity reduction means with the mechanism
- (c) Driving-direction changing means with the mechanism
- (d) Partial-velocity changing means with the mechanism
- (e) Force increasing/reducing means with the mechanism
- (f) Amonut of motion changing means with the mechanism, etc.

[2] Actuators

- (a) Electric power actuator
- (b) Air-pressure power actuator
- (c) Fluid-pressure power actuator
- (d) Heat power actuator

There are provided the following outputting means for the respective actuators (a) to (d).

- (e) Rotation output
- (f) linear-movement output
- (g) Swing output, etc.

[3] Controllers

- (a) Electrical controller
- (b) Electronic controller
- (c) Fluidal controller
- (d) Thermal controller, etc.

The aforementioned respective controllers are prepared as programmable controllers or connection-variable controllers such as replacing pins which enable arbitrarily constructing the circuits thereof.

[4] Sensors

- (a) Electrical sensor
- (b) Electronic sensor
- (c) Magnetic sensor
- (d) Thermal sensor
- (e) Optical sensor, etc.

For the aforementioned respective sensors (a) to (e), there are prepared sensors or auxiliary tools which enable to select the following outputs.

- (f) On/off type output
- (g) Measurement type output

Hereinafter, there will be described exemplary questions and exemplary point allocations on the precondition that the aforementioned elements are prepared.

[Question 1]

"Construct a system for realizing a constant-velocity reciprocating movement under the following conditions."

(The content of movements)

- a. The amount of stroke from a starting point to a target point; 80 mm
- b. The stoppage-position accuracy at the target point; ± 0.5 mm or less
- c. The stoppage-position accuracy at the starting point; ± 0.5 mm or less
- d. Motion velocity characteristics; a constant velocity in the both directions
- e. The time required for moving from the starting point to the target point; 2 seconds ± 0.5 second or less
- f. The restoring time from the target point; 2 seconds ± 0.5 second or less

g. The outputting mechanism ; a linearly-moving table

h. The load; only the weight of the table

i. The content of operations

(ia) A starting switch is used to start operations.

(ib) stoppage for 1 second at the target point, automatic restore

(ic) An end signal is output just after the automatic restore.

(Usable members: these must be selected from the following respective groups)

a. Mechanisms; the group of variably-structured mechanism modules and the group of velocity-reduction units

b. Actuators; the group of electrically-driven actuators

e. Controllers; programmable sequence controllers

d. Interfaces; interface modules

e. Sensors; magnetic proximity sensors

f. Others; clamping mechanisms, connection cables, etc.

(A) The evaluation system for the aforementioned question 1

[potentiometer-type movement characteristics detection system]

Required members

(a) Potentiometer

(b) Interface unit

(c) Personal computer and dedicated software

(B) The content of evaluations

(a) The selection of the mechanism; 20 points

(b) The selection of the actuator; 10 points

(c) The construction of the controller programs; 20 points

(d) The setting and adjustment of the sensor; 10 points

(e) The output movement characteristics; 20 points

(f) The time taken for designing and constructing; 20 points

Total points; 100 points

The aforementioned respective data is automatically processed by the computing portion 1 to evaluate the skill of the to-be-examined person 3.

Fig. 6 is an exemplary designing method which is executed on the screen of the computer.

The reference numeral 30 designates a list representing usable members on the computer screen and they are represented as in Fig. 7, for example.

The to-be-examined person 3 selects members that he considers necessary for the aforementioned question. At this time, the to-be-examined person 3 moves the mouse to the members represented in the list 30, drags the selected members from predetermined fields of the list 30 to display displayable graphics (icons) corresponding to the members, then drags the icons to predetermined positions on the display screen and drops the icons thereat. By repeatedly performing this operation, the to-be-examined person 3 designs an apparatus for the question on the computer screen.

Fig. 6 illustrates a condition where icons are used for designing. A, M, C and S in the figure correspond to the mechanism M, the actuator A, the controller C and the sensor S which have been previously described. Further, there are designated characters such as A (reversible motor), M (connecting rod)....., near the respective icons

and they indicate the contents of the icons illustrated in Fig. 6 for convenience of description. Accordingly, such characters are not always displayed on the actual screen for designing. However, there is no harm in displaying such characters on the screen in view of the convenience to the to-be-examined person 3. Further, the reference character DG in the figure indicates dogs for sensor setting and P indicates a program created by the to-be-examined person 3. Further, the dot lines indicate dragging paths for the convenience of explanation/description and such paths are not displayed on the actual screen.

Next, there will be described an exemplary question at a higher level than the aforementioned question 1.

[Question 2]

"Construct a system for realizing an end velocity-reduction reciprocating movement under the following conditions."

(The content of movements)

- a. The amount of stroke from a starting point to a target point; 100 mm
- b. The stoppage-position accuracy at the target point; ± 0.5 mm or less
- c. The stoppage-position accuracy at the starting point; ± 0.5 mm or less
- d. Movement velocity characteristics; an end-velocity reduction in the both directions
- e. The time taken for moving from the starting point to the target point; 1 second ± 0.2 second or less
- f. The restoring time from the target point; 1 second ± 0.2 second or less
- g. The outputting mechanism ; a linearly-moving table

h. The load; the weight of the table plus loading weights (each weights 750 g)

i. The content of operations

(ia) A starting switch is used to start operations.

(ib) Pause at the target point, an intermediate stoppage signal is output.

(ic) Automatic restore in response to a restoring command signal or after the elapse of 3. 5 seconds.

(id) Finishes the operation if stopping input is recieved between the intermediate stoppage to the end of restoring motion.

(ie) An end signal is output just after the automatic restore.

(if) Automatic restart after the elapse of 4 seconds in the case of absence of a stopping input

(Usable Members: these must be selected from the following respective groups)

a. Mechanism; variably-structured mechanism modules and velocity-reduction units

b. Actuator; air-pressure actuators

e. Controller; programmable sequence controllers

d. Interface; interface modules

e. Sensor; sensors such as transmission-type photoelectric switches, proximity switches, limit switches

f. Others; clamping mechanisms, connection cables, etc.

(A) The evaluation system for the aforementioned question

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[potentiometer-type movement characteristics detection system]

Required members

- (a) Potentiometer
- (b) Interface unit
- (c) Personal computer and dedicated software

(B) The content of evaluations

- (a) The selection of the mechanism; 40 points
- (b) The selection of the actuator; 20 points
- (c) The construction of controller programs; 30 points
- (d) The setting and adjustment of the sensor; 30 points
- (e) The output movement characteristics; 40 points
- (f) The time required for designing and constructing; 40 points

Total points; 200 points

Fig. 8 illustrates the content of design made by the to-be examined person 3 for the aforementioned question, wherein there is illustrated a condition where icons are placed on the computer screen similarly to in Fig. 7. Further, in the same figure, an illustration of the dragging paths and the list are omitted.

While exemplary questions have been exemplified hereinbefore, the basic evaluation criterion for the evaluation of an automation engineer is as to which of the first to fourth generation automation technologies his ability of constructing can realize and therefore it is desirable that the evaluation-point data stored in the evaluation-point data base 18 in Fig. 2 is constructed in view of this point.

While in the aforementioned examples there have been described systems for evaluating the skill of a to-be-examined person in the field of automation technology, the system according to the present invention is not

limited thereto and is applicable to evaluations in other fields by properly setting question data, answer data of the to-be-examined person for the question data and evaluation data for practical skills such as the skill for constructing an actual apparatus.

Further, while in the aforementioned examples there have been described cases of executing the system in a single computer, the system may be configured such that a host computer may be data-linked to plural terminal computers, the terminals may be provided with designing means, questions may be output from the host computer to the terminals, the to-be-examined persons make a design corresponding to the question using the designing means in the respective terminals and the design data may be output to the host computer for evaluating the ability of designing. This enables easily performs ability examinations for the ability of designing on a national basis. Further, when examinations are conducted on a national basis as described above, it is possible to rationally conduct evaluations of ability for constructing an actual apparatus by gathering to-be-examined persons at a predetermined hall, performing actual-apparatus assembling tests and performance tests and the like and outputting the operation data to the aforementioned host computer.

Since according to the present invention, the to-be-examined person creates design data and inputs it to a computing apparatus as an answer for the given question and the design data is directly evaluated by the computing apparatus as skill-evaluation data for the to-be-examined person, it is possible to process large evaluation data within a short time without requiring

many hands and also it is possible to conduct skill evaluations fairly within a short time.

Further, in addition to designing using the computing apparatus, the to-be-examined person constructs an actual apparatus on the basis of the design data, and the performance of the actual apparatus is evaluated to simply evaluate the ability of designing and also the ability of constructing and setting an actual apparatus, which enables evaluations of the skill of the to-be-examined person with higher accuracy and validity. Also, instead of the to-be-examined person, a person who conducts the evaluation or a neutral third person may construct an actual apparatus in accordance with the design made by the to-be-examined person and may designate and record the differences between the characteristics thereof and the target characteristics.

Further, by graphically displaying the placement and combination of respective constituent elements selected by the to-be examined person on a computer device and by converting the content of design made by the to-be-examined person into data using as little language as possible , it is possible to improve the usability of the evaluating system in countries around the world where different languages are used.

CLAIMS:

1. A system for evaluating the skill of a to-be-examined person using a computing device, including:

a computing portion having:

a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and

a means for evaluating the skill of the to-be-examined person;

and

a group of elements for constructing said apparatus designed at the designing means of the computing portion;

wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means, and a means for measuring operating characteristics of the apparatus, such that an ability of the to-be-examined person to design an apparatus and an ability of the to-be-examined person to construct the apparatus is evaluated.

2. A system for evaluating the skill of a to-be-examined person using a computing device, including:

a computing portion having:

a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and

a means for evaluating the skill of the to-be-

examined person;

and

a group of elements for constructing said apparatus designed at the designing means of the computing portion;

wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means, a means for measuring operating characteristics of the apparatus, and a means for evaluating modifications made by the to-be-examined person to the apparatus on the basis of the measured operating characteristics, such that an ability of the to-be-examined person to design an apparatus, an ability of the to-be-examined person to construct the apparatus, and an ability of the to-be-examined person to make modifications to the apparatus is evaluated.

3. A system for evaluating the skill of a to-be-examined person using a computing device, including:

a computing portion having:

a designing means for enabling the to-be-examined person to design an apparatus to operate according to a predetermined question; and

a means for evaluating the skill of the to-be-examined person;

and

a group of elements for constructing said apparatus designed at the designing means of the computing portion;

wherein, the means for evaluating the skill of the to-be-examined person includes a means for evaluating the design made at the designing means on the basis of the elements selected by the to-be-examined person to achieve target operating characteristics of the apparatus and the adequacy of the combination of these elements; and a means for measuring operating characteristics of the apparatus to determine an attainment level of the measured operating characteristics of the apparatus against the target operating characteristics of the apparatus, such that an ability of the to-be-examined person to design an apparatus and an ability of the to-be-examined person to construct the apparatus is evaluated.

4. A system according to any one of the preceding claims, wherein the designing means includes:

apparatus element data having a plurality of mechanism elements arranged in a mechanism data base, a plurality of actuator elements arranged in an actuator data base, and a plurality of sensor elements arranged in a sensor data base;

a controller program creating means; and

a sensor setting/adjustment means.

5. A system according to claim 4, wherein the to-be-examined person designs the apparatus to operate according to the predetermined question by:

selecting one or more mechanism elements from the mechanism data base, one or more actuator elements from the actuator data base, and one or more sensor elements from the sensor data base sensor(s);

creating one or more controller programs with the controller program creating means for controlling the selected elements; and

determining settings/adjustments of the one or more selected sensor elements with the sensor setting/adjustment means.

6. A system according to claim 5, wherein the means for evaluating the design evaluates one or more of the elements selected, the controller programs created, the settings/adjustments of the sensor elements determined, and the time taken to complete the design against predetermined results and generates design evaluation points for the design which are stored in an evaluation point data base.

7. A system according to claim 5, wherein the designing means further comprises a display means for displaying the elements selected from the mechanism data base, the actuator data base and the sensor data base, and the means for evaluating the design evaluates the elements displayed by the display means.

8. A system according to claim 6, wherein the apparatus

is constructed by selecting individual elements from the group of elements, the group of elements comprising a group of mechanisms, a group of actuators, a group of sensors and a group of controllers, and by combining the individual elements in accordance with said design such that the apparatus operates.

9. A system according to claim 8, wherein the means for measuring operating characteristics of the apparatus evaluates the operating characteristics of the apparatus against target operating characteristics and generates operational evaluation points for the apparatus which are stored in the evaluation point data base.

10. A system according to claim 9, wherein the operating characteristics of the apparatus include the accuracy of the apparatus, the operation speed of the apparatus, and the time taken to construct the apparatus.

11. A system according to claim 10, wherein a clock function is provided within the computing portion, or connected to the computing device, to measure the time taken for the to-be-examined person to design the apparatus and/or the time taken for the to-be-examined person to construct the apparatus.

12. A system according to any one of the preceding claims,

wherein the skill being evaluated is an automation technique.

13. A system according to claim 12, wherein the automation technique includes designing and constructing a tool driving/controlling apparatus which causes a tool to apply a target operation to a work element.

14. A method for evaluating the skill of a to-be-examined person including:

presenting a problem to the to-be-examined person, said problem requiring the to-be-examined person to create an apparatus to perform a task;

receiving a design of said apparatus from the to-be-examined person;

evaluating the design;

constructing said apparatus in accordance with the design;

evaluating the performance of the constructed apparatus; and

determining an overall evaluation of the skill of the to-be examined person to design an apparatus and to construct the apparatus to solve the problem.

15. A method according to claim 14, wherein the step of receiving the design from the to-be-examined person includes receiving one or more selections of apparatus elements for

creating said apparatus and one or more controller programs for controlling the one or more selected apparatus elements.

16. A method according to claim 15, wherein the one or more apparatus elements are selected from a plurality of mechanism elements arranged in a mechanism data base, a plurality of actuator elements arranged in an actuator data base, and a plurality of sensor elements arranged in a sensor data base.

17. A method according to claim 16, wherein the step of receiving the design from the to-be-examined person further includes receiving settings/adjustments for the one or more sensor elements selected from the plurality of sensor elements.

18. A method according to claim 17, wherein the step of evaluating the design includes comparing: the one or more apparatus elements selected; the controller programs received; the settings/adjustments of the sensor elements received; and/or the time taken by the to-be-examined person to complete the design, against predetermined target results for the problem and awarding design evaluation points based upon said comparison.

19. A method according to claim 18, wherein the step of constructing said apparatus includes selecting one or more

apparatus elements corresponding to the one or more apparatus elements of the design from a group of apparatus elements, assembling the one or more apparatus elements in accordance with the design, and applying the one or more controller programs to control the one or more apparatus elements such that the apparatus performs said task.

20. A method according to claim 19, wherein the step of evaluating the performance of the constructed apparatus includes measuring operating characteristics of the apparatus as the apparatus performs said task.

21. A method according to claim 20, wherein the operating characteristics include the accuracy of the apparatus, the operation speed of the apparatus, and the time taken to construct the apparatus.

22. A method according to claim 21, wherein the step of evaluating the performance of the constructed apparatus further includes comparing said measured operating characteristics of the apparatus against predetermined target operating characteristics for said problem, and awarding operational evaluation points based upon said comparison.

23. A method according to claim 22, wherein the step of determining an overall evaluation of the skill of the to-be

examined person to design an apparatus and to construct the apparatus to solve the problem includes combining the design evaluation points and the operational evaluation points.

24. A method according to claim 14, wherein the method further includes a step of modifying the apparatus based upon the evaluated performance of the constructed apparatus.

25. A method according to claim 24, wherein the step of modifying the apparatus includes modifying the design and/or the constructed apparatus.

26. A method according to claim 25 wherein the method further includes a step of evaluating the modifications made by the to-be-examined person to the apparatus.

27. A method according to claim 26, wherein the step of determining an overall evaluation of the skill of the to-be-examined person includes evaluating the ability of the to-be-examined person to make modifications to the apparatus.