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Case Study of Convergence Software Considering Aesthetics in Center of Conversion Software Quality in the 4th Industry Revolution Environment

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Abstract: The background of this study began with interest in various technological factors that are diversified in the 4th industry revolution environment. The purpose of this study is to understand and recognize what quality evaluation factors should be considered by the convergence software used in core technologies of the 4th industry revolution and its importance. In order to derive the factors to be considered in the quality evaluation of convergence software used in core technology of the 4th industry revolution which is the interest of this study, we first analyzed the existing software quality evaluation factor. In order to present the quality evaluation factors to be derived a weighting factor considering the factors of the consumer (developer, user and evaluator) a weighting factor considering the cost and a weighting factor model considering the risk are presented. Considering the software evaluation direction, the existing research mainly uses the quality evaluation standard for performance satisfaction and reflects the static quality factor mainly on the result value. On the other hand in this study, it is advantageous to provide the performance criteria reflecting the subjective evaluation of the consumer, reduce the risk factors at the same time and consider all the factors considering the cost factor into the quality evaluation factor. The quality evaluation scale proposed in this study can be applied to software of various application environments such as drone, autonomous vehicle and artificial intelligence. When evaluating software quality it is expected that it will be possible to develop better quality for software by analyzing the big data processing that is predicted in software of the application environment through filtered analysis.

Key words: Software, 4th industry revolution, cyber physical system, big data, engineering, factor

INTRODUCTION

Recently, the issue of the 4th industry revolution has been active. This 4th industry revolution starts with the convergence of information and communication technologies in the industry field. The goal of 4th industry revolution is to contribute to transforming everything into super-connected, super-intelligent societies. In this 4th industry revolution, the core technologies are artificial intelligence technology, object internet technology, robot technology, Nanotechnology, 3D printing technology, unmanned transportation technology (drone-unmanned aircraft autonomous vehicle), media connection technology and display technology. When the era of the 4th industry revolution is complete, the physical, biological and digital environments will be fully integrated. However, in this 4th industry revolution, the concept of Cyber Physics System (CPS) which connects physical world with digital space, emerges. This cyber physics system concept can transform the manufacturing process and control the physical world by using digital technology. In the production process, the existing centralized system is changed into a distributed system. The fact that the centralized system is transformed into a distributed system means that autonomy and diversity are emphasized at the center of autonomy and efficiency. In addition, it implies that vertical management and control center are changed to horizontal control and complementary center. Also there are not emphasizing the complex forms of labor but the labor forms are transformed into simplified forms of labor. In addition, Industry 4.0 features module-centric processes, flexible and flexible plant structure, autonomous and decentralized control forms and wireless mobile communication and real-time location tracking to support multi-product mass production. Germany has been most interested and most prepared for the 4th industry revolution. However, the

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most important factor in preparing for the 4th industry revolution is to draw consensus decision-making at the labor-production site. It is based on the principle of consensus (Kollegialprizip). There are an employee council Betriebsrat, a board of directors Vorstand and a board of directors, Aufsichtsrat to decide on an agreement. Then the principle of this agreement is based on the 1976 Mitbestimmungsgesetz co-decision law.

For the 4th industry revolution, the United States emphasized human-centered technological development, emphasized human resources and elitism in terms of organization. However, the most important thing was to focus on human resources in individuals and organizations. The word here is human resource management. If the non-humanization caused by the domination and control (hierarchy, classification, differentiation, competition) that is the former old organization operating organization lacks creativity and low productivity, the new organization management system emphasizing human respect has been prepared through solidarity and complement (absolute evaluation, autonomy) through high productivity and creativity reinforcement.

Considering the prerequisites for implementing Industry 4.0 it requires a new understanding of human resource management based on human-centered mutual trust in the country and society as a whole. It is based on the mental stability of members and mutual trust and it is important to reach a goal by consensus of all members and to give meaning to commitment. In the operation of the organization, it is necessary to shift to a structure in which roles and responsibilities are emphasized in the status and class and the organizational design as a horizontal structure should be given priority. The emphasis here is on the duties of managers to remove obstacles and encourage members, not punishment or compensation. A new approach to decision-making based on dialogue and discussion consensus is needed and it is required the transition to a customized education system. And the creativity is derived from the harmony of the suggestion class (opinion) which is the principle of consensus. The major feature of Germany's Industry 4.0 is the smart production of network-based information exchange for all manufacturing processes. It is implemented a smart factory to realize this. In addition, the company is building the cyber physics system based on the internet and services, including people, to produce optimal products. Of course in order to realize the optimal Industry 4.0 in the future, it will create environment for the application of cyber physics system (manufacturing industry, communication, energy, transportation, health care, robotics and so on), standardization, cyber security enhancement and a lot of effort is needed to do this. In order to transform into such a society, infrastructure education including creativity, convergence thinking and problem-solving ability is important. In addition to ICT education that can adapt to the future environment, convergence education based on interdisciplinary learning combined with this technical education is very urgent. More specifically, the transition to an education system reinforcing the convergence education capability including the convergence software education is required. In the case of the United States, Minerva School is operated as part of efforts to nurture future human resources and open online education (MOOC) is in operation. In order for the 4th industrial revolution to be successful, it is necessary to create an environment for utilizing big data. Also, it is necessary to change education system and employment environment suitable for environment and to strengthen financial function including accelerating technology development. Likewise, it is necessary to reorganize the industrial structure, to respond quickly to SMEs and to improve the economic system. Based on this background, this study raised the convergence software technology and convergence education direction. The characteristics of the convergence technology age and the 4th Industry revolution were examined. In this environment, the convergence software should have a quality evaluation scale. In order to emphasize that the quality evaluation scale and criteria to be provided by the software should be evaluated considering the aesthetic demands, the risk and cost among the quality evaluation scale required for the convergence software and there are shown in the related Table 1 and as follows in Eq. 1-3. In this study, how should the quality evaluation criteria and standards required for convergence software be prepared in the technical environment of the 4th industry revolution and what aesthetic elements should be provided. In this study, we examined the direction of convergence software qualification criteria and the basic elements of education required in the 4th industry environment.

Literature review: Rong *et al*. (2016) presents about transformation of smart factories and IoT based on 4th industry. This study is a good example of a smart factory as an example of the 4th industry revolution. Saniee *et al*. (2017) studied the potential impact analysis on the productivity of the 4th industry revolution. In this study, Maslow's level of human desire is presented as a hierarchy of transcendence needs, aesthetic needs, cognitive needs, esteem needs, belonging and love needs and safety needs and physiological needs. In this study, we present digital infrastructure networks such as digital

Table 1: Software quality factor

Items/Detailed items	Aesthetics access according to consumer(α)	Relevance of risk (β)	Cost (δ)
Function(f_f( ))			
Completeness	fc	fc	fc
Correctness	fr	fr	fr
Appropriateness	fa	fa	fa
Performance(f_p( ))			
Reaction time	pr	pr	pr
Resource use	pe	pe	pe
Spec (capacity)	ps	ps	ps
Compatibility(f_c( ))			
Coexistence	cc	cc	cc
Interoperability	ci	ci	ci
Usability(f_u( ))			
Appropriateness	ua	ua	ua
Operability	uo	uo	uo
Learnability	ul	ul	ul
Errorprotection	ue	ue	ue
UI aesthetics	iU	iU	iU
Accessability	uc	uc	uc
Reliability(f_r( ))			
Maturity	rm	rm	rm
Availability	ra	ra	ra
Fault tolerance	rf	rf	rf
Recoverability	rr	rr	rr
Security(f_s( ))			
Confidentiality	sc	sc	sc
Integrity	si	si	si
Nonrepudiation	sN	sN	sN
Accountability	sa	sa	sa
Authenticity	su	su	su
Maintainability(f_m( ))			
Modularity	mm	mm	mm
Reusability	mr	mr	mr
Analysability	ma	ma	ma
Modifiability	mo	mo	mo
Testability	mt	mt	mt
Portability(f_y( ))			
Adaptability	ya	ya	ya
Installability	yi	yi	yi
Replaceability	yr	yr	yr

energy, digital health, digital transmission, digital communication and digital production and predict future diffusion. This study adequately analyzes the digital infrastructure in the 4th industry revolution environment. Li *et al*. (2017) researches about the system model of the 3D printing technology community, one of the core technologies in the 4th industry revolution environment. This community research focuses on innovations in design technology community, material technology community, manufacturing support technology community, printer technology community and application of jet technology community and to derive manufacturing molding technology accordingly. However, we would like to emphasize the necessity of the community for an aesthetic point of view which is more important in real 3D printing environment. Individual communities need to manufacture and fuse individual technologies based on aesthetics. Therefore, in the application domain of 3D printing technology, it is emphasized that vehicle manufacturing, aviation, medical device, structural design and engineering, product emphasizing subjective technology, food processing, industry manufacturing emphasizing subjectivity, culture technology emphasizing subjectivity, aesthetics will be very necessary in teaching and other applications. Reschka *et al*. (2011) reviews about software development or open autonomous vehicle systems. This study introduces the process of vehicle software requirements, unit testing, software architecture, software integration testing and verification (Romanovs, 2017). Segatori *et al*. (2017) presents a distributed fuzzy decision tree that should be considered in a big data environment where large amounts of data are transferred in the 4th industry revolution. Distributed binary generation and fuzzy set generation are proposed and node splitting and distributed fuzzy decision tree learning are presented. Narooka and Choudhary (2017) have studied the optimization of search graphs using Hadoop and Linux OS. This study is a study to optimize the search graph in the convergence big data environment and study the swap effect and the search algorithm optimization in the Hadoop framework. This study shows how big data size and swapping data processing are related to each other.

Nie (2017) is working on a value-based model in big data knowledge management collaboration services. This study presents a big data knowledge management service model. In big data analysis, data is created through simplification-filter-clean-transfer-integration and then through purging-clustering -counting-mining-analysis. In this research, the value-driven framework is characterized by the value of knowledge in the service product being included in the process.

Gludovatz and Bacsardi (2016) conducted a study on the products related to IT solutions in the plant operation. In this research, the platform in the framework and solution that supports the decision making process and presents an analysis levels including descriptive analysis (standard report, OLAP), diagnostic analysis (warning and statistical analysis), predictive (forecasting, predictive modeling) and prescriptive analysis (optimization). Pirani *et al*. (2016) reviews about production of IT solution of factory.

Rossmann (2015) conducted a study in which the IoT environment met robotics and automation and presented examples of eRobotics and controllable robot movements. Jacques and Langmann (2016) studied the direction of future education required in the changing times. In the past, if jobs classified as managers, technicians, skilled workers and unskilled workers had a pyramid structure, it would be emphasized that in the future there will be a rhombus structure which with a small number of managers and unskilled workers and with many engineers and skilled workers. We present a dual learning program that can actively cope with this structure. The goal is to eliminate the overlapping part of the education between academic and industry. This program is designed to provide a high-quality, inspired student selected by the industry to participate in class, internships, R&D projects, dissertations and in-depth collaborations between universities and industry. The quality of the student can be observed during the course of the course and it is possible to select among a large number of candidates with high potential and a high-quality engineer with job experience can be obtained. However, this model can be presented as a model suitable for German University and industry environment. Vogel-Heuser (2015) reviewed cyber physics product systems and the industry 4.0 challenge.

Romanovs (2017) reviewed security in the age of Industry 4.0, citing security breaches, cybersecurity trends and countermeasures. We have been able to look at the current situation of the 4th industry revolution from related studies and we have examined the importance of security along with major trends. However, an important issue in this 4th industry revolution environment is that this infrastructure technology will be realized by convergence software technology and what quality evaluation scale or guideline should be applied to this software technology. Therefore, this study will approach the convergence software technical factor, quality evaluation criterion and education direction with this discussion.

MATERIALS AND METHODS

Convergence software technology in the 4th industry revolution environment: Most researchers will be able to prepare images in one of the allowed formats listed above. This study provides optional, additional information on preparing PS, EPS and TIFF files. No matter how you convert your images, it is a good idea to print the files to make sure nothing was lost in the process.

Technology environment of the 4th industry revolution: The 4th industry revolution is a technological revolution and a digital revolution. It changes the business model and production method as well as the super connectivity, super convergence and super intelligence of products and functions. The production of new products is explosively growing due to the convergence of related technologies. To achieve this, a cyber physical system is applied to core infrastructures. The core technologies include technologies such as artificial intelligence, robotics, nano, unmanned body (drones, autonomous navigation), 3D printing, this technology should be the foundation of everything.

Technical elements of convergence software: When dealing with software quality indicators, the factors considered are the three indicators: process, people and technology. The main attributes of software quality include maintainability, operability, reliability, scalability and performance. However, in software execution conditions and operating environment, quality is determined as a result depending on what stimulus causes disorder, makes abnormal situation, what kind of response and how to determine quality factor. Given this response, the designer considers sensitivity and determines trade-offs as well as determine the risk and non-risk. Of course when the software is processed at every verification step, the designer must find and review the hazards found during the process.

However, when dealing with software quality issues, designers must consider aesthetic factors. Occasionally, consideration of this aesthetic element is related to visualization. This visualization problem can take into account visualization and documentation of the source code, visualization and documentation of the process. The main reason for claiming visualization is securing the transparency in the development process and thus securing software quality. In addition, it has the advantage of increasing convenience through automation, ensuring objectivity through quantitative analysis and monitoring development status in real time (planning, completion, change), cost (planning, completion, change), quality (design defect, code defect, (Method, DB, platform, OS), management (process work item, development management tool) and so on.

RESULTS AND DISCUSSION

Convergence software quality indicators in 4th industry environment

Design and quality issues of convergence software: In general, the main quality indicators to be considered for software visualization can be divided into requirements definition, configuration management and dynamic testing (requirements verification, architecture verification) and static testing in the development stage. Here, the requirement verification problem verifies whether the requirements are consistent with the development processor and whether they are implemented correctly in the defined requirements. Appropriate change control should also be made when changes to the shape are made. In user verification, alpha and beta tests are conducted for feedback on quality. In addition, the quantitative verification conducted to ensure the objectivity of the software confirms that the functions are implemented correctly and that the quantitative quality goals are met. Formal verification is performed based on mathematical and logical models with the aim of ensuring software reliability. The architecture validation problem is related to the detection of defects in software code and is done to ensure software reliability. The items in the static analysis will verify that the coding conforms to the standard, meets the software metric criteria and how much code defect rate is in the static analysis. This problem is related to the problem of improving the readability, maintainability and testability of the software code. In addition, the fault tolerance is reflected in the quality index by checking defect distribution through unit of output or area. When we use software quality indicators, we must first determine why we are testing and set up metrics that are relevant to our requirements. It is important to set the major impact factor, although it is a small number when setting the metric. Other factors to consider when setting metrics are clarity and simplicity. We also encourage us to actively use scatter charts, aging charts and trend charts. When evaluating quality, we should have a number of decision bases. It should be objectively testable and include analyical indicators and clearly define when where and how to test.

Quality assessment of convergence software considering aesthetics value: Guidelines for software quality assessment are provided in ISO / IEC JTC1 9126, 14598, IEEE TCSE 730, 1465, 1061, 982.1, ANSI and JIS X 0133. In the process of software that reflects aesthetic value, quality index should use aesthetics as another evaluation scale. Therefore, in the software quality evaluation, distribution information of the average distribution or standard deviation of analysis information such as analysis defects, design defects, implementation defects, test defects and maintenance defects is used for each process. However, this index is an evaluation index that can guarantee some degree of objectivity. In addition, the mean and standard deviation value indices reflecting the ability to correct defects from allowable defects and efforts can also be an objective criterion. In order to create a quality index reflecting the aesthetic value in the design implementation stage, a mean and standard deviation index is made for each item and a logical evaluation index map can be made considering the quality index constant. We are here to emphasize the metrics that reflect the aesthetic value that reflects the needs of the consumer. In general, software quality can be examined in functional, structural and process terms. In terms of functionality, quality assessment can be judged based on whether it meets specified requirements, generates software with few defects, provides good performance is easy to learn and easy to use. In terms of structure, the quality evaluation can be evaluated based on the degree of testing of the code, the degree of maintenance of the code, the degree of understanding of the code and the efficiency and security of the code. In terms of processes, quality assessments can also use according to metrics such as compliance with delivery dates, meeting budgets and providing a sustainable development process that provides reliable software quality.

Therefore, if the quality of function is focused on reducing the amount of software bugs (defects during development period/defects in total period), then the quality of the structure can be defined as a quality standard metrics such as the lines of source code, (the size of the unit that affects analysis or test) or the complexity per unit (the degree of source code complexity that affects system changes or testing), analysis, stability and testability, the degree of unit testing. The quality of process can take into account the processing time, speed and number of cycles or defect rate reduction.

However, if quality is classified in terms of function factors such as performance, compatibility, use, trust, security, maintenance and implant, the following Table can be shown in Table 1. High security risk items should provide strong security services so that they are not exposed or threatened. For example, the software used in a vehicle which is a type of convergence service, has a higher risk of accidents in a running state than in a vehicle parking state, a resting state and a vehicle maintenance state, particularly in a running state on a highway. There is a high risk of accidents, particularly when driving on the highway and can lead to fatal injuries or damage to vehicles. It is necessary to set the weighting value according to the state of the vehicle even when the software quality index is prepared.

To control of modules, the software and data about control of the power unit, cruise system and ABS are the most critical in a driving environment such as a highway. Of course, the software and data that control vehicle safety, on-board diagnostics, tire pressure and the airbag, are most critical when placed in a driving environment such as a highway.

However, the information to update the firmware online is most critical when placed in a maintenance environment. In case of personal ID information, it is critical in highway environments. In case of software and data handling GPS with telematics, there are the most critical in highway environments.

In Table 1, when discussing actual quality indicators, the performance requirements for individual modules may differ depending on the consumer (user α 1, developer α 2, tester α 3, customer α 4 and so on). Particularly, the importance (weight factor) may also be different depending on the usage environment and the state of use. Therefore, this study suggests that it is desirable to determine the quality index constant considering the aesthetic approach weight factor (α), the risk related weight factor (β) and the weight factor (δ) according to the consumer demand.

Therefore, the quality evaluation index f for completeness (f_{fc}( )) among quality functionalities (f_f( )) can be expressed as follows in Eq. 1:

$$f_{fc}() = f_c(\alpha 1, \alpha 2, \alpha 3, \alpha 4) + f_c\beta + f_c\delta \quad (1)$$

When evaluating quality functionality, then we must also consider what weighting should be given between these completeness, correctness and appropriateness. Therefore, the quality equation that takes into account the weight factor (ε, θ, $\aleph$) for functionality can be expressed as follows in Eq. 2:

$$f_f() = \varepsilon f_{fc} + \theta f_{fr} \aleph f_{fa} \quad (2)$$

Now, we can present the following equation considering the weight factor (μ, ν, ξ, o, π, ρ, σ, τ) to create a quality index for convergence software in Eq. 3:

$$f_T() = \mu f_f + \nu f_p + \xi f_c + o f_u + \pi f_r + \rho f_s + \sigma f_m + \tau f_y \quad (3)$$

CONCLUSION

In this study, we started to study the quality evaluation direction of convergence software in the 4th Industry revolution environment. In conclusion, we considered a method to ensure subjective and quantitative quality of software development results by combining aesthetic criteria, risk-based criteria and cost criteria. Learning in the era of the 4th industry revolution is characterized by integrating the causes and results together and integrating the results according to the processes. Like deep running's computer which aims to solve problems more than anything else, the Science, Technology, Engineering, Arts, Mathematics (STEAM) education should be integrated harmoniously, focusing on creative education and emphasizing esthetics. The instructor must be a convergent workforce with technical competence. In this environment, new standards that exceed the conventional software quality evaluation criteria should be presented. In this regard when implementing convergence software training, the developer must first establish the aesthetic criteria of the consumer. Therefore, it is important to reflect the risk weights in consideration of the actual operating environment and conditions of the software. When the output to be developed is presented as a result, it should also be considered that cost which is reflected in the quality evaluation standard. This is because the cost of software is also related to quality as cases are often brought to market without patching the usual software at cost. Also in the era of the 4th industry revolution, the first thing that is required is the processing of big data. In order to develop optimal quality software, big data processing analysis should be done under the proposed environment. It should be ensured that quality software quality is obtained from the refined results and education guidelines for convergence and big data analysis processing should be presented.

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