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Procedia Computer Science 176 (2020) 2125–2132

Procedia Computer Science

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24th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems

Virtual Experiments in Metaverse and their Applications to Collaborative Projects: The framework and its significance

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Abstract

This paper introduces and describes a learning system for analyzing devices in a virtual world and points out its significance for current research collaboration. Now we are in Society 5.0, so daily problems should be solved by IoT (Internet of Things) with a mutual collaboration without borders. The authors need to collaborate with each other among remote organizations and different nations. For such situations, we need to establish the learning system for analyzing devices which would lead to an actual sharing system in the future. In this paper, the proposed concept for the learning system in metaverse is explained. The significance of the system is described, too.

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Peer-review under responsibility of the scientific committee of the KES International.
10.1016/j.procs.2020.09.249

Keywords: Learning system of analyzing devices; remote sharing system of analyzing devices; metaverse; Second Life;

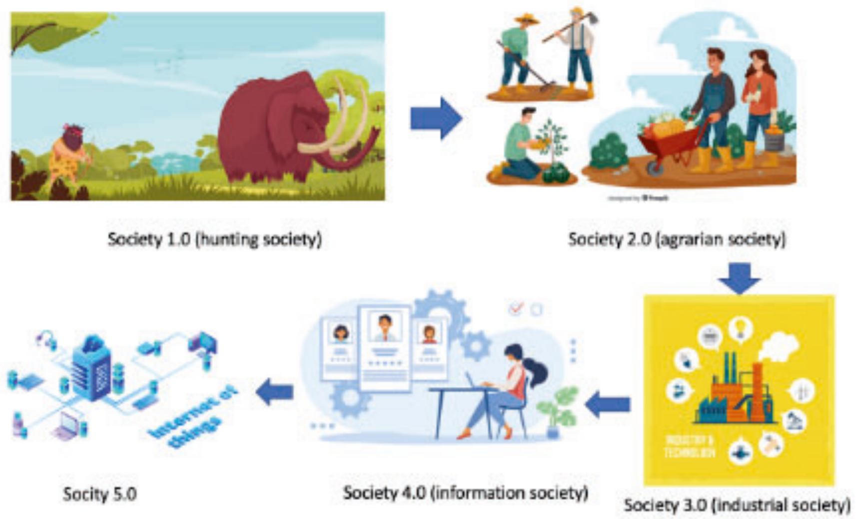

Fig.1 From Society 1.0 to Society 5.0 (Designed by Freepik.)

1. Introduction -Society 5.0 in Japan

The Japanese government recently proposed a new scientific policy called Society 5.0 [1]. This concept resembles that of Germany's industrial 4.0 [2]. According to the Japanese government, the concept is defined as "a human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space" [1]. The Japanese government classifies the development of human civilization into five steps in the concept.

The first step is the society for Hunting & Gathering (Society 1.0) where people lived on hunting animals and collecting plants. It corresponds to the cradle of human civilization until the Neolithic age with agriculture. The second step is the agrarian society (Society 2.0) where the economy is primarily based on agriculture. The third step is the industrial society (society 3.0) where the society's structure is changing from the agrarian to an industrial one, where wealth is increasing for the latter. The fourth step is the information society (Society 4.0) where the information has almost an equal value to various resources in Society 1.0, 2.0 and 3.0. However, such an information society did not share the knowledge and information enough and the mutual collaboration beyond disciplines was lacking. As a result, Japanese societies needed to solve many problems. Then the concept of Society 5.0 appeared, where these weak points in society 4.0 should be solved through the IoT (Internet of things). A variety of information and knowledge should be shared and combined to produce new societal values such as robotic technology and self-driving cars driven by AI technology. (Fig.1). The sharing and its learning systems for knowledge and information should be designed and pursued under the concept of Society 5.0. Such a proposal (particularly, the sharing system of analytical instrumentation) is needed among the authors of this paper for various reasons.

In this paper, our proposed ideas for the Internet are introduced. We explain the background, current problems among us, and why we proposed the system. We believe our proposed method would have applications to many other cases in the world.

2. The background

2.1 KOSEN (National Institute of Technology, Japan) system and the standpoint of Japanese higher organization

The KOSEN system in Japan is a unique educational system. Today, higher educational organization in Japan is classified into three main types: Universities, Junior College, and KOSEN. While the two latter organizations provide two or four educational programs for high school graduates (18 years old in most cases), our KOSEN prepares five - year programs for junior high graduates (15 years old in most cases). After the five- year programs, students get associate degrees and then make life choices, which are generally divided into three types. One choice is to start a job. They have gained practical training in various highly advanced disciplines (in engineering fields, etc.) while pursuing educational programs to earn the associate degree. The students in the second category transfer to universities. They generally transfer to the junior level of the university in most cases, and to a sophomore level to pursue Bachelorette degree programs. As for the Bachelorette degree, KOSEN students get the degree when they enter the advanced course of KOSEN. Fig.2 shows the schematic illustration for the Japanese educational system [3].

KOSEN was established about 60 years ago. The mission then was training, cultivating, and nurturing students, and preparing them to be practical engineers who could solve the problems of societies with their practical skills and advanced knowledge. The original mission has not been changed and KOSEN still produces engineers in Japan. Now the graduates occupy the core of engineers in Japan. These graduates are several tens of percentages of the entire number of engineers in the country of Japan. Just as general universities in the world developed and changed their missions in societies (from the organization just for knowledge transmission to that of producing innovation of science and technology), KOSEN also needs such a change. This will not only fulfil the original mission, but also enhance the quality of higher education. To achieve the purpose, we need the advanced form of academic-industrial alliance.

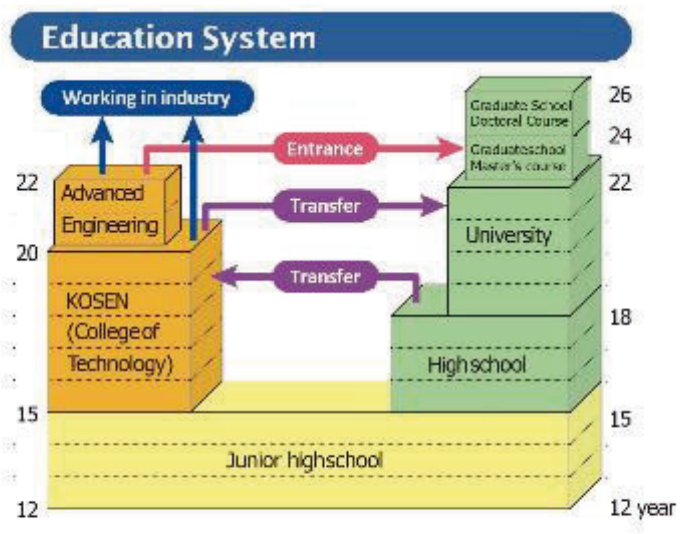

Fig.2 Japanese educational system

2.2 The concept for a KOSEN research center and the significance of research collaboration on a national scale

As described in the previous section, KOSEN, a unique higher education system, is now changing to be composed of 50 or more colleges that are dispersed all over the country. Fig.3 shows the location of each KOSEN in Japan. The network of KOSEN is spread out all over the country, as shown in the figure. It suggests the successful possibility for an academic-industrial alliance with the research topics all over the country. At the same time is the new problem of how so many KOSEN colleges could share the information with each other, and integrate their software, etc. and hard facilities, along with providing a feeling of unity.

Fig. 3 KOSEN network in Japan (Designed by Vector/Freepik.)

Based on this background, we need to promote the research activities more to establish a sharing system among all branches, and an effective remote, control system to share the apparatuses as well as the information [4-10]. Even though we described the background focusing on domestic problems, the needs for international collaboration are required too. In such a case, the remote sharing system will be needed much more. At the same time, COVID-19 problems sadly emerged. They dismembered the geographical connections and disconnected information. The necessity for the sharing and integration is required more now.

2.3 *The sharing system for advanced analytical instrumentation techniques and apparatus*

From the background described, we need to establish the sharing system for analytical instruments and information among KOSEN networks and for international collaborations. Particularly, the remote sharing system of analytical apparatus is very important for collaboration involving materials science and areas related to chemistry. The research collaboration in these fields almost always needs analytical apparatus. When researchers help each other by using their skills and an exchange of information, they should share concrete images of the apparatus and instructions for using it. Therefore, the sharing systems of analytical instruments are technical matters, as well as the core of collaborations involving information and knowledge. We present three kinds of sharing systems for remote collaborations.

The first one is that the researcher A (without the instruments) physically moves to the institute of researcher B and operates the apparatus of researcher B by himself/herself.

The second one is the collaboration by snail mail. Even though this method may be rather primitive, this has been the most effective way so far. The researcher A prepares the sample for the analysis on a remote place. Then the researcher sends it to the researcher B who has the apparatus. The researcher B analyzes the sample of researcher A by his/her apparatus and sends the data back to the researcher B by mail or email.

The third one is the remote control of apparatus. In this system, the researcher A could operate the apparatus of researcher B through the Internet and obtain data in cyberspace. This is closely related to the concept of the Society 5.0. However, all methods are a sort of sharing system to pursue the collaborative research beyond geographical, organizational, national and any other differences.

As shown above, there are various possibilities for sharing analytical instruments with each other. However, the most important matter is the mastership and proficiency of the apparatus in advance. Otherwise, researcher A would not get a chance to operate the apparatus in either of these ways, nor to analyze the data as a result. To achieve our purpose effectively, there are also many possibilities. To directly utilize the remote control might lead to troubles like breakage and unpredicted accidents. Therefore, we decided to focus on virtual reality and particularly on metaverse.

Fig.4 3D virtual world (Second Life)

Fig.5 Various virtual objects could be used.

3. Preparation

3.1 Metaverse and its application to educational projects

Metaverse [11-15] is the three-dimensional world where avatars are active on behalf of users in the real world, as shown in Fig.4. Usually, the virtual world composed of computer graphics is accessed by users with appropriate personal computers and a special application (a viewer). For these projects so far, we utilized Second Life (SL), one of the representative examples of metaverse. The service has been run by Liden Lab Co. with the headquarters located in San Francisco, the US. People may tend to consider this a sort of game. However, the essence is different from just a game world. The unique characteristics are as follows:

#1: The digitized structures can be made in virtual reality.

In this virtual world, the user can produce many digitized contents, using so called “Prims” or “Primitives”. In Second Life (SL) virtual objects are composed of a unit, i.e. the prim. When various prims with a certain color, texture, brightness, shapes etc. are combined with a certain combination of parameters, such as the position, size, rotation etc., virtual objects could be produced in the metaverse. Fig.5 shows the example scene of our experimental project from the past.

#2: Mutual communication in the metaverse is possible just like that in the real world.

In Second Life, many styles of mutual communications are possible. At the early stage, only chatting using text message was possible. However, the verbal communication method was developed and nowadays, the communication in Second Life is very similar to that in the real life, except for the lack of a face-to-face situation.

Avatars do everything on behalf of users. As for the text message communication (chatting), we carried out the multi-national collaboration projects with different languages where we developed a translation system.

#3: The possibility of simulating various real-life activities in Second Life.

Using the two characteristics, a lot of social activities become possible such as stores, museums, parks, shopping malls, theaters, hotels, cruisers, research institutes etc. No need to say anymore, the user could participate vividly in the social and virtual activities with a strong sense of reality.

With all of these unique characteristics mentioned above, we carried out various education projects [16-31]. However, we made a project plan to establish a learning system for advanced analytical instrumentation.

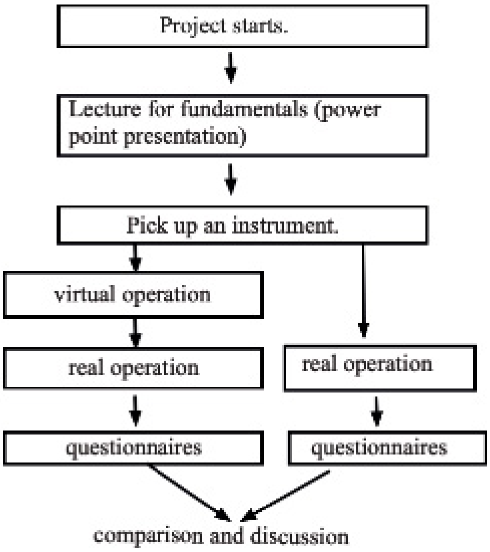

Fig.6 The scheme for the trial experiments.

3.2 Trials at this point.

Fig.6 shows the architecture (flow chart) of the virtual system.

Firstly, we should have the virtual classroom for researchers having the experimental apparatus to explain the general presentations and prepare the presentations using power point files. Speakers and participants could exchange their messages verbally or with the text-based messages in the virtual classrooms shown in Fig.5. The readers may be wondering why we need such a classroom facility. The most important reason is that we would like to give the participants the vivid sense of reality, which must lead to the enhancement of the learning effect to the maximum. To learn through an avatar's movement in real-like classroom facilities, participants should be much impressed. We could expect successful learning for the basic theory and the general sketch for the analytical instrument.

Secondly, we will choose some experimental apparatus and produce the virtual objects whose appearances look like the real one. Since we just started the project at this point, we cannot show the concrete model for the system. For example, a Raman spectroscopic analysis could be picked. When the participant would click various functional buttons, the text would pop up to explain what kind of function the button would express. At this point, the prim-based object has not been built, we will continue to build prim-based virtual instruments one by one and carry out the trial utilization.

And finally, participants would have the virtual training. The examinees would be classified into two groups. The first group would have the virtual training and then they would have the real- world training. The second group would have the real- world training without the virtual one. For both groups, we will give the participants questionnaires. The outlines for the questionnaires are mentioned below. Basically, their impressions will be evaluated by five scales.

#1: Did you understand the basic theory for the analysis?
1. Very much, 2. Pretty much, 3. Neutral, 4. Not so much, 5. Not at all
#2: Did you feel the sense of reality?
1. very much, 2. Pretty much, 3. Neutral, 4. Not so much, 5. Not at all
#3: Did you understand how to operate the instruments?
1. Very much, 2. Pretty much, 3. Neutral, 4. Not so much, 5. Not at all

#4: Did you understand how to analyze the data?
1. Very much, 2. Pretty much, 3. Neutral, 4. Not so much, 5. Not at all
#5: Were you interested in the analytical instrument?
1. Very much, 2. Pretty much, 3. Neutral, 4. Not so much, 5. Not at all

The trial would be repeated for some instruments, respectively and the results would be analyzed and discussed for each group.
Using the results, we would discuss the effect of virtual training.

4. Future Scope

In this study, the learning system project for sharing analytical instruments among remote places and different organizations was discussed. We focused on metaverse to achieve the establishment of a virtual learning system of how to operate the analytical instruments through the Internet to achieve the purpose. The system is needed to realize the mutual research collaboration among remote researchers and engineers. We made the scheme and are now preparing for the experimental trials. At the next step, we will produce some analytical instruments by using prims in metaverse and carry out the virtual training. By comparing the combination of virtual and real -world training with a certain instrument, we will be able to evaluate the effect of a virtual training system on the understanding of the instrument usage in the real world.

Acknowledgements

This work was supported by JSPS KAKENHI (Grants-in-Aid for Scientific Research from Japan Society for the Promotion of Science, Grant Number 19K12246.) A part of this work was supported by GEAR 5.0 Project of National Institute of Technology (KOSEN) in Japan. We thank the National Institute of Technology (NIT KOSEN) and NIT (KOSEN) Suzuka College for allowing us to use their web pages. We also appreciate GEAR 5.0 and thank Freepik for the use of some figures.

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