Hybrid Agent Tutor Model for e-Learning System with Interactive Robotics

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Abstract. In this paper, we propose Hybrid Agent Tutor Model (HATM) simulated with robotics to enhance an e-Learning system for education field, especially science and technology. We applied advanced simulation technology and interactive robotics into the proposed e-Learning system. In this system, hardware robot agents in real world and software agent in virtual one were defined as the Hybrid Agent Tutors (HATs), and will perform interactive relationship so as to support learners to get more efficient educational contents. Based on this concept, we configured a simple prototype system to show frame work according to noble “Qualia” and “Awareness”, and estimated the efficiency of this system in the e-Learning.

Keywords: Hybrid Agent Tutor Model, Simulation, Interactive Robotics, e-Learning, Qualia, Awareness, Interactive Man Machine Interface

1. Introduction

The e-Learning system is provided by utilizing the internet with high-speed and large-capacity as a main component. Learners can receive their required knowledge through a PC anywhere and anytime. In the classroom of universities, it would be an acting and thinking place to utilize the knowledge as the wisdom to solve problems and create new idea. Various kinds of examinations are accomplished about the new system of the higher education including universities as an educational reform action [1, 2]. For example, MOOC (Massive Open Online Course) is going to change the conventional class-style of university, and this is called a Flipped Classroom [3, 4, 5, 6]. In the classroom of higher educational organization, especially universities, it would be an acting and thinking place to utilize the knowledge as the wisdom to solve prob-
problems and create new solution. We regard that the expectation and the importance to the framework and contents provided in remote learning environment increase more and more. In the construction of education framework and contents for learners of science and technology, in particular, it is difficult to expect enough learning effects only by giving knowledge such as a spoon feeding. We need to cultivate a discovery power and a solution power by experiencing thought and creation. In this paper, we propose Hybrid Agent Tutor Model (HATM) simulated with robotics to enhance an e-Learning system for education field especially science and technology. We utilized advanced simulation technology and interactive robotics in the target e-Learning system. Hardware robot agents in real world and software agents in virtual one are defined as the Hybrid Agent Tutors (HATs), and will perform interactive relationship so as to support learners to get more efficient educational contents. We implement two new concepts such as “Qualia” and “Awareness” those come from brain science and psychology to enhance the target e-Learning system [7, 8]. “Qualia” is a texture of experimental reality based on human’s activity. At the first stage of e-Learning, learner will accumulate the knowledge with experimental reality such as “Qualia”. “Awareness” is a presence of collaborative person in a target group. In the second stage of e-Learning, learners make a virtual group connected with internet to create new solution and make a group decision with a feeling of presence about collaborative persons such as “Awareness”. We think both two concepts are very important items to enhance e-Learning for virtual group education system. We implemented simple prototype of e-Learning system and contents, and estimated the efficiency of new e-Learning system. This system gives us a suggestion that advanced simulation technology and interactive robotics have a high potential to support for a smart e-Learning system, especially in the education contents of science and technology field.

2. Component of New e-Learning System

The popularization of Note PC and internet enables us to set up the e-Learning terminal equipment without any difficulties. We can get various e-Learning contents through Note PC connected with internet. In conventional e-Learning system, e-Learning content is displayed on Note PC. On the display of Note PC, learners can observe a content of target subject and get a related knowledge and small examination to check the recognition status and level by using examination check function on pop-up window. In this paper, we propose new e-Learning system features about terminal equipment, learning step and virtual group operation as follows. We propose tutor model for the e-Learning system to realize a new function by applying a multi-method simulation technology and elemental technology of the interactive robotics complementarily. In the proposed e-Learning system, we put both Note PC and robot as an e-Learning terminal equipment. Figure 1 shows the combination of Note PC and robot as a terminal system of e-Learning. Note PC is connected with internet, and displays the content of the target
e-Learning subject. Robot is also connected with internet, and supports the learner to study the target e-Learning content. We configure this robot as an Interactive Tutor Robot (ITR) to have a communication with learner. Attached robot has a powerful interactive function to realize various communication method with learners.

![Combination of Note PC and Robot for New e-Learning System](image)

Figure 1: Combination of Note PC and Robot for New e-Learning System

3. Tutor Model for New e-Learning System

In this paper, we propose tutor model for e-Learning system to realize a new function by applying a multi-method simulation technology and elemental technology of the interactive robotics complementarily. In the target e-Learning system, we recognize tutor’s function is important to support learners, then we applied a robot as a tutor so as to enhance the efficiency of e-Learning system. We describe several models of tutor in the target e-Learning system as follows.

3.1. Multi Method Simulation Tutor

We adopt “AnyLogic” (XJ technology) as a simulation tool for the target e-Learning system. It supports following three simulation models with suitable abstraction level.

(1) Discrete Event Model (DEM)
(2) Agent Based Model (ABM)
(3) System Dynamics (SD)

In this simulation, we can co-simulate with the combination of above models. For example, in the model of the production and the consumption, we describe the production process in Discrete Event Model (DEM) and consumption model performed in target market describes in Agent Based Model (ABM). By utilizing this co-simulation, we can grasp the whole system in optimized abstraction level. Figure 2 shows a co-simulation example of production and the
consumption. In this example, we assume home electric appliance as a production model in the product line of the factory. And we carry out simulation as a series of flows by behavior such as the movement of the half finished product, work of the procurement of each part, each assembling process in DEM. In addition, in the consumption model, we carry out simulation using ABM about the situation of the consumption when an electric appliance made in product line was spent by the market. In the ABM, consumers are called agents and are defined as a host behaving in interaction with the environment autonomously. For example, we can compile the behavior patterns of consumers into a database by programing the level of the consumption behavior. For the action of external environment such as the public relations, we create a parameter of the agents beforehand.

In this paper, we performed a trial to apply this "production and consumption" model, and to provide basic learning matter in the design and development of the robot as education contents in the e-Learning. The robot is basically classified into three functions as sensor, processor and actuator. We can consider it an embedded system and think that is suitable as a teaching material which included required elemental technology for learners of science and technology. In addition, we include hardware and software, mechanism and elemental technology such as the control, and simulate the behavior of agent in various kinds of environment with a robot comprised by those combinations. Figure 3 shows the example of co-simulation between the design and development model of the robot and an action model in applied environment.

Figure 2: Co-simulation between production and consumption

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Figure 3: Co-simulation between Robot Design and Community with Robot
The design and development process model of a robot simplified for learning is simulated in DEM, and a robot in the applied environment is simulated in ABM. In the ABM, the robot produced by a learner is defined as learner agent. Furthermore, we define the agent with tutor function as a tutor agent, and feed-back actualized problems and refinement to a learner as a result of interaction of both. In this way, the learner learns an assembling process and the control flow of a simplified robot in DEM and can discover problems and a refinement through the behavior of the robot agent in the ABM.

### 3.2. Interactive Robotics Tutor

We extend the ABM function to add the new agent. Conventional agent in simulation is described by using programming language. And new agent called hardware agent is described by transferring the parameter from real robot, and performs as a tutor agent in ABM simulation environment. These parameters are created from the conversation between robot and human. Robot has a suitable function to mediate the real world and virtual world. We selected the robot named “NAO” (Aldebaran Robotics) used for education and research field because of its feature specification that supports software development environment and powerful communication function with human [9, 10]. Figure 4 shows the example of 3D simulation environment for robot “NAO”. “NAO” is a humanoid robot, and software development environment is enriched and has a good reputation as the interactive robot which strengthened a communication function again. In addition, the utility that we work and simulate in the 3D environment is provided.

![Virtual NAO in 3D Simulation](image1.png) ![Real NAO](image2.png)

**Figure 4:** 3D Simulation Environment for NAO
3.3. Hybrid Agent Model Tutor

We use above-mentioned simulation tool “AnyLogic” and interactive robot “NAO” complementarily, and define the technique that we simulate two kinds of agent interactively in ABM as Hybrid Agent Model Tutor (HAMT) [11]. Figure 5 shows a conception diagram of the Hybrid Agent Model Tutor (HAMT) simulation environment. We can co-simulate two kinds of models of Discrete Event Model (DEM) and Agent Based Model (ABM) in the simulation environment that utilized “AnyLogic”. In DEM, we can define constitution and the control flow of the target system definitely, and process flow chart is used as a visual tool for programming input language, and each behavior is possible to act independently with the behavior of other processes [12].

![Figure 5: Hybrid Agent Model Tutor simulation](image)

It is ABM that a robot constructed in DEM is simulated the behavior and interaction with the environment in the virtual space that assumed the really used environment. Agent is defined on ABM by utilized state diagram in “AnyLogic”. Furthermore, we utilize a real robot and we extract a parameter through the conversation with the human and “NAO”, then define it as a character of agent. We define the former as a software agent, the latter as a hardware agent, and define the model using agents of these two kinds as Hybrid Agent Model Tutor (HAMT). The interaction with learner agent which a learner made occurs between software agent tutor and hardware agent tutor. Among tutor agents, the information of the behavior parameter is shared and cooperation movement is carried out. We can get a simulation result to satisfy expectation if we simulate interaction only for software agent when we can express the behavior of the agent in the target environment that is the place where a robot acts by an established pattern. In the case that agents act various behavior patterns, it is required to add individual agent that is created from real world and sampling parameter as a special treatment. We consider it is
effective way to find the solution against the problem. As a way to realize this idea, we proposed to utilize the real robot which strengthened a communication function, and to use the information from the communication with human as a behavior parameter of robot in simulation world. The designed robot finally acts in the real world, we can expect improvement of the simulation quality by taking information of the real world as an action parameter of agents before submitting the robot to the real world.

4. Implementation of new concept

It is an advantage that the e-Learning system can transcend time and space constraint as the remote education environment with internet. On the other hand, in virtual education environment, it is a difficult problem how we realize the real feeling of education materials and the atmosphere feeling of the collaborative members in group. In a real meeting classroom, we can feel it naturally without any special conscious about them. We regard these senses are important concept for learners to get a sense of accomplishment and to perform the cooperative task in the group. Therefore, we perform an action to implement "Qualia" and "Awareness" in the education system of science and technology. Those are concepts to be used as one technique for realization in brain science and a psychological field. The "Qualia" means the feeling of a material based on the subjective experience. The "Awareness" means the feeling that we take in existence and the atmosphere of the collaborative members without any special attention in a group. In an e-Learning of conventional style, we thought it is difficult to realize two concepts of “Qualia” and "Awareness". So we performed consideration to bring close to a sense of the real world by the following action. Figure 6 shows the concept of “Qualia” and “Awareness” realization. In the first stage of the learning in the e-Learning system, learner mainly makes an effort toward the acquisition of the knowledge in the style of the individualized learning. There is an advantage that learning progress is done with the required speed of the learner in the learning. However, it is the serious problem, for example, such as taking on the teaching style of so-called spoon feedings or pouring a knowledge one-sidedly, or forwarding memorization. The knowledge which was gotten in this way doesn't turn to the style to discover a problem and to create the solution, even if it is valid in the memory check of the case index such as a memorization examination. A sublimation from the knowledge is required, where learner needs the accumulation of the information with the texture which is based on the experience having to do with personal sense of entity. We take a trial to implement "Qualia" as the concept to express this texture. By utilizing interaction between robot and human as the specific realization means, in case of acquiring an information, we perform the approach which improves the texture.
Next, in the second stage of the learning in the e-Learning system, learners form a virtual group with other learners connected with internet, and perform a group learning. In the place, as the field which applies the knowledge accumulated in the first stage of the learning, proposed idea is brushed up for the debottlenecking and the exchange of views among the learners. One of the parameters to do a group learning smoothly is the presence of the collaborative learner. In case of the condition that learners join in the same room in physical, learners feel the collaborative learner’s presence without any special conscious. However, in the virtual group where learners connected with internet, it is a hard issue to get such a feeling. We performed the trial to implement "Awareness" as the concept to express the presence of the collaborative learners. Then, in the group learning, it is one of the idea that tries the approach which draws out the presence of collaborative learners. Shared information about the ambient atmosphere of learners is gotten by interaction between robot and human. As the specific realization means of the other learner’s presence via robot in group learning, we tried the approach to implement the concept of “Awareness” that draws out the presence of the collaborative learner. The learning effect, it is hard to estimate in the conventional e-Learning system, can be expected in higher level by implementing two concepts of "Qualia" and "Awareness". We think that the utilization of Interactive Tutor Robot (ITR) in the proposed system is valid as the realization means of collaborative learner’s texture in virtual group learning.

Figure 6: Concept of “Qualia” and “Awareness” realization
5. Case Study for Prototyping

We configured the case study of prototyping by applying advanced simulator and interactive robot for our target e-Learning system. Figure 7 shows overview of new e-Learning system that consists of e-Learning content based on simulator and Interactive Tutor Robot (ITR). The e-Learning content is provided by utilizing advanced simulator that performs both Discrete Event Model (DEM) and Agent Based Model (ABM). We selected robot construction and operation for the target e-Learning subject. Robot construction process is described in DEM simulation. Robot operation in target field is described in ABM simulation. We also applied Interactive Tutor Robot (ITR) to support learners by making interactive connection among learner, real robot and virtual robot.

5.1. Example of e-Learning Flow that applies Robot Construction

We consider the society or community where robot is acting as a case study for prototyping. When we construct robot in DEM, parts database and the library database of the function block that consists of mechanism and the control flow for robots are prepared as contents for education beforehand. And we realize a simulation to assemble a robot of the constitution to adapt to the field of target environment by using DEM. In addition, we utilize a process flow and an animation function of DEM so that the constitution of each part images it in chronological order and three dimensions. In the environment where the robot acts in such as society and the community, the robot constructed in DEM is considered to be one agent and is simulated in ABM. In the ABM, we simulate the behavior of the interaction among agents. According to the behavior of the robot agent in the target environment, a learner knows the effect and reflect problems and a refinement of products as new needs in DEM. Figure 8 shows the example of the learning flow that assumed robot as the teaching materials.
In this example, main process consists of five parts as follows.

1. **Target Robot Selector**
   Learner will select the target robot that is used in target community or field such as senior welfare, house-keeping, team playing game and emergency rescue, etc.

2. **Mechanical Block Composer**
   Learner will select the suitable mechanical block to compose the target robot body.

3. **Control Block Composer**
   Learner will select the expected control block to set up the control sequence on the target Robot.

4. **Agent Profiling Tuner**
   Learner will tune-up the profile of Robot agent then submit it to ABM simulator.

5. **Agent Interaction Scope**
   Learner will observe the Agent behavior in ABM simulation.

These series of actions, it allows the learners to know about the combination of functions of the robot and the control flow. In addition, it enables to know that the robot behaves what kind of ways in target environment and what kind of influence occurs in a target environment. The character of the agent in the target environment is made as a typical model in a library beforehand. We take a parameter extracted from a real robot in the real world and the communication with human. In simulation environment, we can realize the interactive behavior with the real environment. It performs the interface between real world and virtual world and enables to establish synchronization of the behavior of the virtual robot and the behavior of the real robot.
Recently, robots are used for various application fields such as industry, public infrastructure and home use. We selected home use robot for our simple prototype in the proposed e-Learning system. Figure 9 shows examples of home use robot such as luggage carry, sweep & clean and home security. These home use robots are displayed in the selection table of the e-Learning content. We simplified the specification of target robots for the e-Learning content. Basic specification of each target robot is configured as follows.

![Variation of Home Use Robot for e-Learning Contents](image1)

Figure 9: Variation of Home Use Robot for e-Learning Contents

1. **Luggage Carry Robot**
   This robot consists of base chassis with two wheels driving, optical sensor and touch sensor. This robot is used for carrying the small luggage in house.

2. **Sweep & Clean Robot**
   This robot consists of base chassis with two wheels driving, optical sensor, touch sensor and sweep & vacuum cleaning module. This robot is used for room with vacuum cleaning function.

3. **Home Security Robot**
   This robot consists of base chassis with two wheels driving, optical sensor, touch sensor and camera sensor. This robot captures the image data by embedded camera sensor and transfers the image data via internet.

![Types of Robot Construction](image2)

Figure 10: Types of Robot Construction

Learner selects the target robot in this selection table, and observes the construction process flow that is performed by applying DEM simulation model. We consider two types of construction of robot. First one is belt conveyor type. Second one is work bench type. Figure 10 shows
both types of robot construction. In the case of belt conveyor type, target robot is constructed by robot arm with single function. Target robot is also not complicate. Learner will learn sequence how to attach each parts in this process flow. In the case of work bench type, target robot is constructed by robot arm with multi functions. Target robot is complicate in its construction parts and process. Robot arm will show both sequence of construction and geometric position of each parts on attached body of target robot. Robot arm can perform as an avatar of learner.

Learners study the process flow of robot construction to observe the 3D animation in execution mode of simulation. Figure 11 shows the step of robot construction according to specified sequence. In first figure, right driving unit is attached by robot arm. In second figure, left driving unit is attached by robot arm. In third figure, optical sensor is attached by robot arm. In fourth figure, touch sensor is attached by robot arm.

![Figure 11: Step of Robot Construction](image)

After completing the robot construction, learner can observe the behavior of target robot in virtual space. Figure 12 shows behavior of target robot in living room and private room. This simulation is executed in ABM. Virtual space data can be stored in library. Searching path of each room is pre-fixed on simulation script in system with several path pattern data list in simulation system. Learner can observe the behavior of target robot in 2D or 3D simulation window. In addition, another agent can be characterized in same simulation so as to make an interaction with agent robot.

![Figure 12: Behavior of target robot in living room and private room](image)
The proposed e-Learning system simulates the elemental technology of a robot construction and the control flow in DEM. It will be functions as the learning stage of the first step in a learner. In addition, the robot which is the work of the first step has the role of the agent in ABM simulating the cooperation as the second step. We can observe the interaction with the existing agent in the target environment. In this way, the learner can observe it what kind of ways the robot agent of the specifications that oneself constituted behaves in target environment. We can reflect the result as a parameter to simulate it, and to carry it out in DEM again.

We apply co-simulation system to realize “Qualia” by experimental reality effect. Figure 13 shows the example of e-Learning content that performs path searching system. Searching path is described in two dimension maze map. And we put path search robot as an agent of co-simulation environment. We give the path information to the robot which is defined as an agent in the simulation. In the execution mode in simulation, two types of camera angle can be observed an actual running stage. The first one is "the birds-eye view". The learner observes the running status of the robot from the viewpoint of observer. The second one is "the robot view", the camera is attached to the robot. The camera eye of the robot is synchronized with the learner. With this, learner can get the actual feeling to search the path by himself. By using this function, the texture based on the experimental reality can be realized.

5.2. Interaction between Human and Robot

In the proposed system, robot will perform as a tutor. Learners will get various assist from tutor robot. Figure 14 shows the interaction between robot (tutor) and human (learner). The interaction between robot and human consists of two direction of message transfer. First one is from robot to human, we take robot’s gesture in visual, voice and effective sound in audio. Second one is from human to robot, we take human’s face look and attitude in visual, voice in audio, touch in feeling. In the proposed e-Learning system, we specially focus robot’s gesture.
In addition, we can reflect a real environmental parameter by transmitting the parameter of an agent extracted from real “NAO” and the communication with human. To utilize interaction of human and robot, we realize the "Awareness" by dynamics effect of the robot gesturer. Figure 15 shows the editing system for robot’s gesture. In this example, we utilize the gesture of the robot to transfer the message from robot to human. The right hand of the robot is moved as the gesture with the meaning of "How do you do?", also head moves up and down. The tracking line of the embedded actuator in head and arms of robot is shown in the diagram chart. In this chart, the curve shows the tracking line of the actuator. The learner’s impression can be changed by editing the position of the peak point in this diagram chart, and by cooperative action of the actuator in the arm.

Figure 15: The editing system for Robot’s gesture

(1) Configuration of Robot’s Gestures
Figure 16 shows examples of robot gesture those are used to assist learners in the e-Learning system. (A) means greeting gesture with the message “How do you do?”. (B) means
facing hard problem with the message “It’s a difficult problem.” (C) means agreement with learner’s opinion with the message “Let’s try it upon your idea.” (D) means admire of learner’s job with the massage “You did it!”.

Figure 16: Examples of Robot’s gestures

(2) Continuous Pauses in Time Slot

Figure 17 shows disintegrated capture image of robot gesture in chronological order. It will start from left side to right side. Gesture of robot consists of continuous pauses in fixed time slot. In the actual gesture of robot, time factor between each pause is a key factor to give a different feeling to learner. For example, when robot nods his head quickly and up his head slowly, on the other hand, when robot nods his head slowly and up his head quickly, the impression of learner will be different. Also the synchronization of head and arms is key factor to make a feeling of gesture. We configure this as a dynamic effect of robot’s gesture. We utilized this effect to enhance the e-Learning efficiency.

Figure 17: Captured image of robot gesture (to start from left side)

Learner performs several reactions after getting any massage from tutor robot. We consider how to evaluate learner’s reaction by utilizing embedded sensors in hardware robot. Figure 18 shows the evaluation system for learner’s reaction.

(a) Visual Function

NAO has 2 sets of camera sensors on its head block. Camera sensors are located vertically, on the upper side of robot face and lower side of robot face. It will be able to monitor learner’s face expression and attitude. It will perform human’s eye function. To memorize learner’s face data, face detection is also available. To evaluate learner’s reaction, robot will provide suitable suggestion and comment to learner.

(b) Audio Function

NAO has 4 sets of microphone in front, right, left and rear side of head block. And has 2 sets of speaker on right and left side of head block. It will perform human’s ear and mouth functions. Voice recognition and voice synthesis are available to make a communication with human. To analyze the reaction voice of learner, robot can generate suitable suggestion
and comment message to learner.

(c) Touch Sensor Function

NAO has 3 touch sensors in head and both arm block. When learner will touch head or arms of robot, NAO can recognize this touch action. It enables to evaluate learner’s reaction that perform the physical body contact action between humans.

(d) Ultra Sonic Sensor Function

NAO has 4 sets of ultra-sonic sensors in chest block. Although human has no sensor function like this, it enables to detect the presence of learner in front of robot. This function has a potential to utilize in group learning stage.

Figure 18: Evaluation System for Learner Reaction

Figure 19 shows visual inspection by using new Man Machine Interface (MMI) based on interactive robot “NAO”. This function is used in visual and operational inspection process in robot construction phase. In visual inspection process, learner touch the head of real robot “NAO”. The action of real robot “NAO” is linked with agent robot in robot construction process. Learner can observe the agent robot figure in various view point by forcing the head of real robot. Figure 20 shows operational inspection by using new Man Machine Interface (MMI) based on interactive robot “NAO”. Learner touch the both arms of real robot “NAO”. The action of real robot “NAO” is linked with agent robot in robot construction process. Learner can drive the agent robot to required direction by forcing the both arms of real robot. Real robot “NAO” performs as a remote controller with new Man Machine Interface (MMI). We configured this new interface as an interactive Man Machine Interface (MMI).
We applied hardware robot for a new Man Machine Interface (MMI) in the proposed e-Learning system. In conventional e-Learning system, the interaction between learner and e-Learning system is performed in display panel with mouse as a pointing device. Mouse is a popular pointing device in conventional PC system. We configured the robot as a tutor, and studied how to realize effective interface between human and robot. We applied robot as an interactive Man Machine Interface (MMI) for the proposed e-Learning system.

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Figure 19: Visual Inspection by using new MMI based on robot

Figure 20: Operational Inspection by using new MMI based on robot

Figure 21: Actuator and Sensor function on Real Robot
Figure 21 shows actuator and sensor function on real robot. The head and arms of hardware robot are originally specified to make a certain motion by controlling embedded actuators in robot. In proposed case, we configure the invert function on this actuator. In hardware robot, we use the DC motor as an actuator. This motor can perform as a generator to create the input signal from learner. When learner catch the hand of robot and force to turn right or left, embedded motor generate the electrical signal according to learner’s action. We utilize this signal as an input signal from learner and transfer to software robot. In this interface, learner can feel experimental reality to control virtual robot more effectively than mouse. By applying robot itself as a remote controller, it will be possible to realize flexible and interactive Man Machine Interface (MMI) in target e-Learning system.

Figure 22 shows interactive Man Machine Interface (MMI) based on robot. In this case, learner catches robot’s hand and force to turn clockwise direction. Embedded DC motor will create electrical signal. This signal is transferred to virtual robot via internet. Learner can send a control signal to virtual robot. At the same time, virtual robot will create response signal to the actuator of hardware robot. Learner will feel real-time reaction from hardware robot. It creates new interactive feeling about Man Machine Interface (MMI). We configure this interface as an interactive Man Machine Interface (MMI).

6. Result and Discussion

At the first stage of e-Learning, we provide individual learning environment to learner. Learners can receive tutor’s advice and guide by applying co-simulation model. Then learner makes decision by himself or herself. Contents of e-Learning are created by co-simulation of DEM and ABM model. In the proposed e-Learning system, we selected robot construction model and apply constructed robot for home use such as luggage carry, sweep & cleaning and home security. Learner gets an experimental reality by using this co-simulation technology as an e-Learning content. Finally it will be realized the concept “Qualia”. At the second stage of e-Learning, we provide group learning environment to learners. Tutor robot provides the suggestion to learner to indicate the direction about group discussion and review. As the means of utilizing the robot which strengthened a communication function as a tutor and realizing interaction of human (learner) and robot (tutor) effectively, we can make sure the possibility that robot will perform the coordinator in virtual group. As a result, it will be one of the valid means
which attempts for "Qualia" and "Awareness". The approach of installation as the concept to improve the learning effect of e-Learning to be realized was confirmed and could get a new barometer. Also, we have gotten the prospect regarding to the implementation ability about the extension of the framework for the e-Learning system. The building approach of a new coordination and configuration for the e-Learning system can be expected. By the improvement of accumulated knowledge with texture of experimental reality at the stage of individualized learning and by applying accumulated knowledge to solve the target problem in virtual group, we had a possibility to establish new collaborative e-Learning system in virtual group operation. Also, we think that it gives an important suggestion toward the incoming new communication system in the community with coexistence and coordination between human and robot. That seems to increasingly become more important in the future e-Learning system.

7. Conclusion

We proposed the framework that complementarily utilized simulation and robotics as an educational contents in the e-Learning system. In the proposed e-Learning system, both hardware robot and software robot are configured as a Hybrid Agent Tutor (HAT). For a prototype of case study, we implemented the mechanism and the control flow of the robot into the e-Learning contents for learners of science and technology. We estimated three effects such as experimental reality, dynamics of robot gesture and interactive Man Machine Interface (MMI). It makes possible to learn experiential reality and group communication with such as a concept of “Qualia” and “Awareness” in the e-Learning system. To learn software and hardware generally and operate the virtual robot in target society and community, it gives an important suggestion in future society, where human and robot will coexist and cooperate.

References

[1] T. Popkov and M. Garifullin : Multi-approach Simulation Modeling: Challenge of the Future, Systems Modeling and Simulation—Theory and Applications, A (K. Koyamada, S. Tamura, O. Ono eds.), Springer, Heidelberg, (2007), 103-107.

[2] I. Grigoryev : AnyLogic 6 in Three Days: A quick course in simulation modeling. Any Logic, North America, 2012.

[3] Y. Tokiwa and H. Sumitomo : The current state of e-learning in universities and proposals for the next generation, PROVISION No.35 / Fall 2002, (2002), 64-73. (in Japanese)

[4] N. Capuano, S. Miranda, and F. Orciuoli : E-Learning at Work in the Knowledge Virtual Enterprise, Intelligent Collaborative e-Learning Systems and Applications. SCI (T. Daradoumis, S. Caballé, J.M. Marquès, F. Xhafa eds.), 246, Springer, Heidelberg, (2009), 53-63.

[5] I. Lutkebohle, J. Peltason, L. Schillingmann, C. Elbrechter, S. Wachsmuth, B. Wrede, and R. Haschke : A Mixed-Initiative Approach to Interactive Robot Tutoring, Towards Service Robots for Everyday Environ, 76, (2012), 483-502.
Y. Matsui, M. Kanoh, S. Kato and H. Itoh : Generating Interactive Facial Expressions of Kansei Robots Using Simple Recurrent Network, The Robot Society of Japan Journal, 28:3, (2010), 360-368.

M. Tye : Visual Qualia and Visual Content Revisited: revised from Visual Qualia and Visual Content, The Contents of Experience (T. Crane ed.), Cambridge University Press, Cambridge, (1993), 447-456.

E. M. Robertson, A. Pascual-Leone, and DZ. Press: Awareness Modifies the Skill-Learning Benefits of Sleep, Current Biology, 14, (2004), 208-212.

NAO next generation user guide EN 11-2012. Aldebaran Robotics, Paris, 2012.

A. Loulouidi, A. Mosallam, N. Marturi, P. Janse, and V. Hernandez : Integration of the Humanoid Robot Nao inside a Smart Home: A Case Study, in International Federation of Robotics, Executive Summary of World Robotics 2009, Sweden, 2007, 35-44.

T. Tojo, O. Ono, N. B. M. Noh, and R. Yusof, Hybrid agent tutor model for e-learning system with robotics, AsiaSim 2014 (S. Tanaka et al. eds.), 474, Springer, Heidelberg, (2014), 301-309.

N. B. M. Noh, R. Yusof, O. Ono, and T. Tojo, Feedback preferences in case-base construction for intelligent lab tutor, AsiaSim 2014 (S. Tanaka et al. eds.), 474, Springer, Heidelberg, (2014), 291-300.