Service Cooperation and Co-creative Intelligence Cycle Based on Mixed-Reality Technology

Takeshi Kurata, Masakatsu Kourogi, Tomoya Ishikawa, Jungwoo Hyun and Anjin Park
Center for Service Research, AIST
kurata@iee.org

Abstract-In order to make Mixed-Reality (MR) and Augmented-Reality (AR) technologies widespread, it is necessary to establish a framework for service cooperation and intelligence cycle in which digital content including virtualized real-world models improves the performance of real-world sensing, and meanwhile the sensing services contribute the efficiency of content gathering and authoring. In this paper, we introduce our own works to enjoy such synergy by facilitating cooperation among services such as pedestrian navigation, patrol inspection, interactive modeling, behavior analysis and service redesign based on MR, and also by co-creatively circulating knowledge among service consumers, providers, and other stakeholders.

I. INTRODUCTION

Mixed Reality (MR) is a comprehensive technical field that addresses not only virtualization of real-world entities such as human, object, and environment, but also information presentation considering consistency of real-world entities and virtual entities such as virtual objects and annotations in terms of geometrical, optical, temporal, and semantic aspects according to their necessities. In addition, MR treats the virtualization-presentation cycle with various granularities.

However, in order to make MR and Augmented-Reality (AR) technologies widespread, we have to establish an efficient framework for service cooperation and intelligence cycle in which digital content including virtualized real-world models improves the performance of real-world sensing, and meanwhile the sensing services contribute the efficiency of content gathering and authoring. In this paper, we introduce our own works to enjoy such synergy by facilitating cooperation among services and also by co-creatively circulating knowledge among service consumers, providers, and other stakeholders.

II. MIXED-REALITY TECHNOLOGY AND SERVICE ENGINEERING

When we overlook the continuum of MR [7] along with the co-creative service-design cycle (Fig.1-bottom), AR, which is the micro-cycle based on the real world right in the front of users, can be regarded as a technology for application-observation loop. On the other hand, Augmented-Virtuality (AV), which focuses on high-fidelity and large-scale virtualization of the real world and also on the utilization of such virtualized real-world content in the virtual environment, can be regarded as a technology for supporting observation-analysis-design loop. By this means, MR technology has the potential to support the improvement of the service productivity by augmenting the experience and intuition of service users and providers. However, we need to raise the ease of social implementation of MR more and more for its popularization as described below.

For instance, pedestrian navigation services and operation-assist services based on AR technologies (Fig.2-upper-center, Fig.3) [1-4] are both highly intuitive application-observation loop technology. and simulation and evaluation in AV environments as in Fig.2-lower-right, Fig.5 and Fig.7 [4, 8] are Mieruka (visualization) for supporting observation-analysis-design loop. To raise the ease of social implementation for the former, we need to consider the compatibility between restraint of maintenance costs for sensor infrastructure and high-accuracy sensing. Also, for the both cases, we have to tackle restraint of creation and maintenance of the virtualized real-world content.

III. MR-LIKE AND CO-CREATIVE INTELLIGENCE CYCLE

One of our own works dealing with the problems mentioned above is the development of the interactive indoor modeler (Fig.2-lower-left) [5] using a single image and several constraints included in the image. This approach facilitates the co-creative intelligence cycle by various factors as follows.
1) If users have a digital camera, a PC, and a short time, they can easily create virtualized real-world environments such as their house, office, store, etc. in a photo-realistic way (Fig.2-lower-left).

2) It is possible to realize the following virtuous cycle:
   A) Sensing accuracy can be improved by applying the virtualized real-world model to map matching using the probability distribution of the user existence (Fig.2-upper-right) and also to model-based image recognition.
   B) Modeling efficiency can be more improved by gathering the model material with high-accuracy sensor.

3) Information presentation can be more intuitive as for the simulation and visual data mining (Fig.2-lower-right, Fig.5 and Fig.7).

4) The framework of co-creative intelligence cycle can be constructed by distributing the modeler and by providing storing and sharing services for the created models.

5) Those models might be able to become a part of the service infrastructure if the models are used for the 3D map, and then annotations are added on them. It would reinforce the motivation of the creation and maintenance as in social-contribution and self-realization.

6) Even if we begin the intelligence cycle with the relatively small one, its cycle has the value for the various benefits as mentioned above, and moreover if the intensive model input is performed by a large capital, the growth of the cycle can be boosted.

IV. EXAMPLES

In the case of field research on the exhibition guide services using a PDA for the Science Museum (Kitanomaru park, Tokyo) as shown in Fig.3 [6], the electronic worksheet encouraging real exhibition experience is deeply involved with co-creative intelligence cycle especially. Museum attendants have the case in which they have to do repeatedly the same explanation and also the case in which they have to communicate with visitors according to the responses and the circumstances. As e-worksheets can be easily made for the repetitive explanations, it is possible for museum attendants to manage their time better by presenting such e-worksheets in accordance with the status of visitors. To realize it, it is demanded the service and the assistive technology for reducing the load of preparing e-worksheets and also for...
promoting its cycle. If we can provide the attendants with a computer-aided e-worksheet-design service based on real-time sensor data and resources such as 3D maps, photos with attributes as in the shooting position and orientation, behavior log, etc., it is possible for them not only to produce e-worksheets, but also to establish the condition on how to present them (the recommend method) with the PDA efficiently. In addition, by providing visitors with the same e-worksheet authoring service, it is expected that we can establish a co-creative intelligence cycle which circulates e-worksheets that are difficult to create from attendants' point of view.

In field research of the pedestrian navigation system for visually-impaired person (Fig.4) [1], we have integrated image processing techniques with GPS, Wi-Fi positioning, and PDR to estimate the position and orientation of the user. It is really important to prepare the image database (DB), since the position and orientation of the user are estimated by obtaining the correspondence between shooting input images on the spot and each image stored in the image DB server including shooting position and orientation, reliability of the photographer, and attributes as in the usage log. The image DB can be shared with the navigation system for physically unimpaired person, and it is technically possible to add a large number of images already existing on the web that contain the attributes as in GEOTAG into the DB. With intelligence cycle like that, we can expect to improve social implementation of walking support system for the blind.

It is effective that patrol inspection service cooperates with remote monitoring service using surveillance cameras in facilities such as factories, shopping malls, etc. (Fig.6) [4]. The 3D map can be used to support constructing the DB of attitudes for RFIDs and surveillance cameras as in the position and orientation. Also, it is possible not only to modify the position and orientation of service users and providers who wear a PDR module, but also to overlay ID tags on images by combining the trajectory extracted from the images taken by a surveillance camera with the PDR data.

As described above, as in pedestrian navigation services and working support services at a wide area, we can say that repetition of locomotion by walking and relatively simple work is one of the most frequently occurring situations in daily lives and services. We have developed the omni-directional walk-through simulator (WTS) for reproducing such situations in the lab (Fig.2-lower-right, Fig.7) [8]. The WTS can also realize subjective evaluations according to typical scenarios one of which is that, for instance, the subject moves to some destination while holding a map or a handheld
device, and by having a conversation with employees, etc., since The WTS provides the subject with the following features: the preservation of sense of absolute orientation (prevention of VR sickness), the hands-free control by footfall, and body rotation, the communication function with others by photo-realistic avatars, convenience of duplication by compact and ease mechanism. Moreover, it can be applied to the visual-data-mining interface by overlaying the 3D map with various kinds of log data and predicted values. If we can utilize service fields just as a laboratory, the service design by service engineering approaches is expected to become much more efficient. Meanwhile, intervention in service fields is accompanied by human cost and risks of disturbing normal operations in particular. We expect that service providers will be able to intuitively perform the service design with relatively low cost by combining 3D models, sensor logs, and WTS as mentioned above.

V. CONCLUSION

Nowadays, the sudden upsurge of AR applications is very fascinating the author as well. In the AR application fields, the improvement of sensor accuracy will be considered more in public after circulating AR-related content sufficiently just as mobile phones equipped with GPS was popularized after the web brimmed with GIS content, since such GPS phones can make the efficient exploitation possible.

The popularization of AR technologies and applications is expected to accelerate more and more if the framework of service cooperation and co-creative intelligence cycle described in this paper will be kept constructed at that occasion since it brings the high service productivity and the ease of social implementation. It is not so difficult to imagine that greater service cooperation and intelligence cycle could be produced if MR technologies will be involved in the trend.

Fig. 6. Automatic video tagging as an enhanced function of patrol inspection service by cooperating with wearable tracking service.

REFERENCES


Fig. 7. Walk-through simulator (WTS).