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A novel application in guiding assembly task: augmented reality animation

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Assembly task is an activity of collecting parts/components and bringing them together through assembly operations to perform one or more of several primary functions. Part drawings are still performing as the main means for assembly guidance nowadays. Researches have indicated that drawings assembly consumed a mass of invalid time and also found that 2D drawings relatively failed to consider the cognitive issues comprehensively. While conducting a series of physically workpiece operations (kinaesthetic activities), an assembler should also conduct several mentally manual-related processes (cognitive activities) such as comprehending, translating and retrieving information context (Neumann & Majoros, 1998). The time allocated to each portion was measured by Towne (1985), who came to the conclusion that the cognitive activities accounted for 50 percent. Besides, confined in fixed-size two dimensional (2D) drawings, a large quantity of information concerning product parts and components can be quite redundant, cumbersome and crowded, especially when the comparatively complex assembly tasks are referred. Last but not least, apart from the consumption between physical and cognitive process, mental tiredness can come into being after a long exposure to the drawings, since information retrieval difficulty generally exists in complex assembly drawings, especially to the novice assemblers (Gick & Holyoak, 1980).

As the development of computer graphics, Virtual Reality (VR) has emerged. Notwithstanding, regardless of the considerable assembly accuracy, this software-guided method also manifests its defects. For instance, VR-based method cannot provide a better understanding of diverse interferences of assembly path and complex real assembly environments. The issues such as assembly task difficulty and assembly workload could not be easily evaluated either. In fact, although VR-based method could significantly improve people's the perception about the geometrical features and spatial locations of components in assembly task and considerably lower the difficulty in components cognition and information retrieval than assembly drawings via technological change of 2D to 3D, the projections of three-dimensional images on a computer screen are still the approximate versions of real spatial entities. What is more, another shortcoming is the limited level of "realism" experience due to the lack of rich sensory feedback (Wang & Dunston, 2006). The computer-generated virtual components cannot convey other channel of useful feedback such as audio, tactile, and force, etc., which normally exist in the real world.

Another promising alternative is Augmented Reality (AR) technology, with which a technician can manipulate the virtual components directly inside the real environment. The potential interferences between the to-be-assembled objects and the existing objects in the real assembly environment could also be identified. Notwithstanding, current trials have not eliminated the assemblers' cognitive

workload. A reasonable explanation is the limitation of registration technology (Caudell & Mizell, 1992). Accordingly, to acquire the sequent information context such as assembly paths and fixation forms of components (augmented clews), the assemblers still need positive cognitive retrievals before reorganizing these augmented clews in mind. In order to address this long-standing and critical cognitive problem, the rest of this paper introduces a more developed form of the traditional AR called AR with animation (rather than abandoning the mature AR technology), and argues its unparalleled potentials of being guidance compared with manual, VR and AR.

The thread is to integrate the dynamic animation with the existing AR facility, and make them as a dynamic augmented tool to guide the assembly task. Technologically, the prototype involves the effective setup and implementation of AR facility, including an immersive HMD, pre-defined paper-based markers, an interactive computer graphics modelling, animating and rendering software (3ds-max), ARToolKit and its attached library OSGART, which combines the well-knowing ARToolkit tracking library with OpenSceneGraph and simplifies the applications of Augmented Reality. Next, the virtual counterparts of the real entities acquired from 3ds-max will be plugged into OSGART. Following, the locomotion along virtual assembly path of each virtual component will be registered into the real components using the ARToolKit, OSGART and paper-based markers. Last but not least, the significant parameters of the to-be-assembled and assembled objects will be graphically and synchronously shown as the forms of hint and notation, e.g., parts/components texture, weight, color, specification and so on. The proposed AR facility would allow an assembler equipped with a HMD to either "step into" the assembly space or in some similar fashion to have his or her view of a real assembly augmented with virtual entities. According to augmented animation segments, the assemblers equipped with HMD could see the whole process where the to-be-assembled virtual objects move towards the already-assembled real objects along the pre-defined assembly paths and could pick the real to-be-assembled component from numerous components with great ease.

This paper will firstly elaborate the great potentials of using AR animation in guiding assembly task, which can be reflected in the following three aspects.

1. Reduced attentional transfer and kinetic operations
2. Improved spatial cognition and lowed cognitive workload
3. Be as a media for proficiency enhancement

Besides, experiments of evaluating the cognitive effectiveness of adopting such a novelty in assembly task will also be presented in this paper. The target of experiment I is to study the effects of the merging of virtual entities into real environments on the nature of a person's cognitive performance as compared with a pure virtual environment and a pure real environment respectively. The target of experiment II is to investigate if task proficiency is increased from AR animation to real work task.

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