Assembly Retrieval Results Inspection in Immersive Environment

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Abstract

This poster presents a research aimed at supporting the browsing through the results of an assembly retrieval system by exploiting Virtual Reality technologies. To support the users' understanding during the assessing of the similarities of 3D assembly models, the proposed system exploits the three-dimensionality of the space to locate the retrieved models distributing them according to their dissimilarity to the model used as query. It also allows the users to interact with assemblies through voice and gesture commands, which resemble gestures well-established in touch user interfaces. Through them, users can see correspondences between assemblies, disassemble and re-assemble 3D digital models, such that it is possible a better inspection of the assembly components that is the first step for the development of systems allowing for their modifications and combinations.

CCS Concepts

• ***Information retrieval*** → *Evaluation of retrieval results; Users and interactive retrieval;* • ***Human computer interaction (HCI)*** → *Interaction techniques;* • ***Visualization*** → *Visualization application domains;*

1. Introduction

Information visualization has become an important research topic in many application fields. It includes not only the visual presentation of the information but also the study on the interaction modalities to facilitate the data comprehension and assessment. Its importance in the browsing of digital libraries has been recognized to navigate among the elements in the library and facilitate the retrieval of the desired content. In this perspective, the here presented research is aimed at exploiting immersive virtual reality environments to easy the inspection of the results of a search query in a CAD (Computer-Aided Design) assembly models dataset for supporting their reuse.

VR solutions for content-based retrieval exist for images, e.g. [NH01], and 3D parts [HMP*14]. In the first case 3D space allows a better organization of the content according to the selected similarity criteria (e.g. color, content). In the second case, it allows a better visualization and organization of the retrieved elements. As for images, the difficulties behind CAD assembly model retrieval are due to the multiple criteria characterizing the similarity. Indeed, considering two models as similar depends on the objective of the user, which may consider different assembly characteristics, such as the shape of its components, their mutual relationships or the assembly structure. Therefore, it is important that a retrieval system is able to deal with all the interesting characteristics in the similarity assessment.

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Generally, retrieval procedures act in three stages: (i) model processing for the computation of a descriptor suitable for further comparisons, (ii) descriptors comparison and (iii) results visualization. The first two steps are achieved through the retrieval system proposed by Lupinetti et al. in [LGMP18a], where the user set a query model and the similarity criteria to be fulfilled, then the similarity is evaluated according to different criteria and at different levels (i.e. global/local). Here, we focus on the third stage introducing a novel interface to present and analyze the results of a retrieval system. A first visualization of the results has been provided in a desktop solution [RLG*17], where the results are presented in a flat manner such that to understand which similarity characteristics are predominant all the results have to be analyzed. To overcome these limitations, we exploit a VR environment such that many models can be displayed together, providing the user the possibility of comparing models in their original dimension interacting with them in a natural way. The proposed VR system will not only allow the user to accessing, interacting and analyzing with digital models but also modifying them and eventually compose new models.

2. Methodology

The visualization of the results must consider two different aspects: how the information is *communicated* to the user (section 2.1) and how the user can *interact* with the system and in particular with the 3D models (section 2.2). Hence, the purpose of the proposed VR system is to exploit the 3D space to realistically and naturally manipulate complex CAD models as well as to increase the understanding of the associated information.

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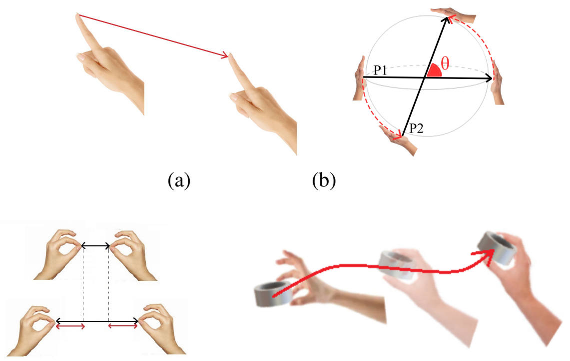
(a) (b)

Figure 1: *(a) "Results browsing scene": the query and the gazed models are ringed in yellow and in purple respectively;*
(b) "Inspection scene": user manipulates the selected part (highlighted in green) and can ask for highlighting the correspondent parts in the query and in selected assemblies, which are shaded with the same color



(a) (b)

(c) (d)

Figure 2: *Gestures: (a) Drag for translation; (b) Hands open for rotation; (c) Pinch for uniform scaling; (d) Hold for free movement*

The user accesses the VR environment by a HTC Vive head mounted display (HMD), where natural interactions are allowed through the use of vocal instructions and Leap Motion hands-tracking controller for hands-free motions capture.

2.1. Communication

The first communication of the results is performed by a spatial metaphor according to which the assembly models are arranged in the 3D space such that models closer to the query model are more similar than farther models. Hence, each assembly is located in a specific point of the 3D space according to the values of three similarity measures $\overrightarrow{\mu} = (\mu_{shape}, \mu_{joint}, \mu_{position})$. In this way, the Cartesian coordinates x, y and z of a general point will reflect respectively the three measures of similarity (shape, position and joint). We refer to [LGMP18b] for details on their computation. In addition, to enrich the communication, several elements furnish the space: three colored columns projected on the walls display the exact values of the three measures; two gray-colored columns display the percentage of the matched elements over the number of parts in the query and the compared model respectively; arrows show the directions along witch the measures decrease. An example of the proposed representation is shown in Figure 1(a).

2.2. Interaction

The developed interactions aim to be as much natural and intuitive as possible. To achieve this goal, the proposed VR system supports interactions without controllers by exploiting the human gaze, the movements of the hands and the voice.

Object selection Object selection is performed in two steps: target acquisition and selection confirmation. In the proposed system it is possible to select entire assembly models or their single parts; in both cases, the user is guided by the change of the color of the object hit by his/her gaze. Then, either the voice command *select* or the gesture *tap* performed with the index finger confirm the selection.

Gestures To facilitate the analysis and the inspection of the results, it is possible to manipulate with hand movements the virtual models as depicted in Figure 1(b). The hand gestures illustrated in Figure 2 allow the following manipulations: (a) translation by keeping right hand with the index extended and the other fingers closed; (b) rotation by keeping hands opened with the palms facing each other; (c) uniform scaling by keeping hands with the thumb and the index pinched; (d) free movement by grasping the selected object.

Voice commands The proposed VR system adopts also voice commands as shortcuts, for instance to confirm the selection, change the measurement accuracy, undo the last performed transformation or come back to the previous scene.

3. Conclusions

The objective of the presented research is the definition and set up of an immersive environment for the analysis and the manipulation of complex assembly models, where users easily interact with models and their components, possibly adding modifications and eventually compose new models. As a first step, VR technologies are exploited to distribute the retrieved models according to their distance from the query one highlighting the characteristics that determine the similarity. Voice and gesture commands have been implemented to allow their analysis while modifications will be the subject of future research.

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