Development of Educational System for Automotive Engineering based on Augmented Reality

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Abstract

In this paper, an augmented reality system for automotive engineering education is introduced. Main objective of the system is teaching disassemble/assemble procedure of automatic transmission of a vehicle to students, who study automotive engineering. System includes vehicle transmission, set of tools and mechanical facilities, two video cameras, computer with developed software, HMD glasses and two LCD screens. Developed software gives instructions on assembling and disassembling processes of real vehicle transmission with the help of augmenting virtual reality objects on the video stream. Overlaying of 3D instructions on the technological workspace can be used as an interactive educational material. In disassembling process, mechanical parts which should be disassembled are augmented on video stream from video cameras. Same is done for assembling process. Animation and other visual effects are applied for better indication of the current assembling/disassembling instruction. During learning and training, student can see what parts of vehicle transmission and in which order should be assembled or disassembled. Required tools and technological operations are displayed to a student with the help of augmented reality, as well. As a result, the system guides a student step-by-step through an assembly/disassembly sequence. During educational process a student has an opportunity to return back to any previous instruction if it is necessary. Developed augmented reality system makes educational process more interesting and intuitive. Using of augmented reality system for engineering education in automotive technology makes learning process easier and financially more effective.

Introduction

Modern science and technology requires high quality of engineering education. Therefore, developing new interactive educational systems based on achievements of information technologies is a challenging issue. Application of augmented reality technology is on of the possible ways for improving educational process.

Augmented reality (AR) is a field of computer research which deals with the combination of real-world and computer-generated data (virtual reality), where computer graphics objects are blended into real footage in real time. One of the first applications of the augmented reality technology was first introduced by T. Caudell in 1992 [1]. It was used for to improve the efficiency and quality of human workers in their performance of manufacturing activities. Augmented reality quickly became popular among researchers, engineers, designers, etc. It was successfully applied in robotics [2], medicine [3], automotive and aerospace engineering [4], and many other areas [5]. One of the possible applications of augmented reality is shown in Fig. 1.

Fig. 1 Augmented reality technology is used for architecture and design.

There have been several researches and projects on application of augmented reality in educational and training system. Interactive virtual laboratory for training was presented in [6]. In [7], augmented reality was used for guiding and evaluating of easy assembling process. Experimental evaluation of augmented reality in object assembly task was done in [8]. More advanced user interface based on augmented reality was proposed in [9].

As it was shown in previous researches, augmented reality is a useful tool for improving educational and training systems in assembling guiding tasks. However, in previous applications of augmented reality were used only in easy assembling operations. In this paper, we are going to describe the educational training system for assembling and disassembling of automatic vehicle transmission based on augmented reality technology. First, we briefly introduce augmented reality technology and proposed system's structure in section "System structure". Second, algorithm of assembling an disassembling with the help of augmented reality is described. Then, application of developed educational system is presented. Future work and conclusion are given at last.

System Structure

Main idea of augmented reality is augmenting the real world scene with the objects of virtual reality. In developed system ARToolkit was used for processing augmented reality [10]. ARToolKit is a software library for building Augmented Reality (AR) applications. These are applications that involve the overlay of virtual imagery on the real world. The ARToolKit video tracking libraries calculate the real camera position and orientation relative to physical markers in real time. This enables the easy development of a wide range of Augmented Reality applications [10].

We used ARToolkit to develop the system which can guide a student during assembling or disassembling of the automatic vehicle transmission. Automatic transmission from Hyundai Sonata vehicle was selected (See Fig. 2). Hyundai Sonata is one of the most popular vehicles in the korean automotive market. Therefore, teaching students whose major is automotive engineering how to operate with transmission from the selected vehicle is a relevant task.

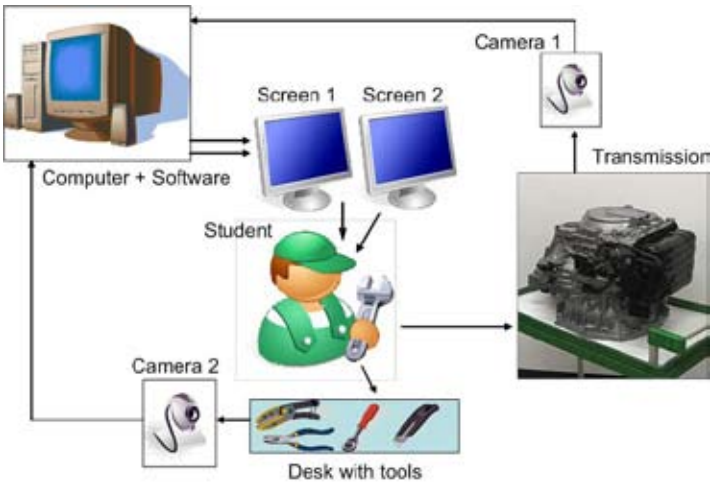
Fig. 3 shows two steps of conventional way for transmission disassembling. Student or worker does this process following the paper manual. Manual includes more than 100 pages and describes hundreds of steps. Manual can provide only 2D simplified drawings and schemes. That is why for a student it can be very difficult to learn assembling or disassembling with the help of manual. In this case, there should be a skilful person who will instruct and properly guide a student through the process. This way of teaching is uncomfortable, not intuitive and expensive. To solve this problem we propose interactive educational system.

Fig. 2 Automatic transmission from Hyundai Sonata.

Fig. 3 Conventional disassembling process

In Fig. 4, the structure of proposed augmented reality setup for teaching assembling/disassembling of automatic transmission is shown. It includes automatic transmission, two video cameras connected to desktop computer, two LCD monitors and set of tools. Image of transmission is captured by one of the cameras and sent to the computer. Specially developed software analyze each video frame and augments virtual objects and instructions to it. Finally, resulting frame is displayed on the monitor. Similar is done for the desk of tools. Second camera captures the view of the desk with tools and after all image processing image with tools is displayed on the second screen. Tools which are required during disassembling process are highlighted with the help of augmented reality. As a result, student can see virtual reality instructions on the screens and follow them step by step.

Fig. 4 Structure of developed training system



Algorithm

In this section, we describe the algorithm and software which we have developed. There are two continuously running processes in the designed system, as it is shown in Fig. 5. First process was responsible for augmenting virtual instructions for assembling and disassembling. USB camera captured the view of transmission. Two markers were attached to the desk where transmission was placed. AR Toolkit library was detecting and localizing markers. After required coordinate transformation was done virtual objects were augmented with the help of OpenGL. Mechanical parts of real transmission were modelled as combinations of simplified 3D objects. Animation was used to show proper directions of moving of disassembled parts and tools. Almost all virtual models of mechanical parts were rendered as transparent objects. That allowed to achieve better visualising performance due to merging real part with its virtual model. Fig. 6 shows virtual objects and tools augmented to the video image of transmission.

Second process of the system was providing information about required tools. All tools and mechanical facilities were arranged on the desk. USB camera captured the top view from the desk with the tools. Coordinate transformation is done in order to locate position of each tool on the desk. Location of the required tool on the desk was indicated on the screen via augmenting blinking rectangle on the screen. View of the tool's desk with augmented indication is presented in Fig. 7.

Displaying the virtual instructions and indication required tools are done synchronically based on the input from the student. At each step student can select the following control options: display previous step, repeat current step, display next step.

Fig. 5 Algorithm of developed system

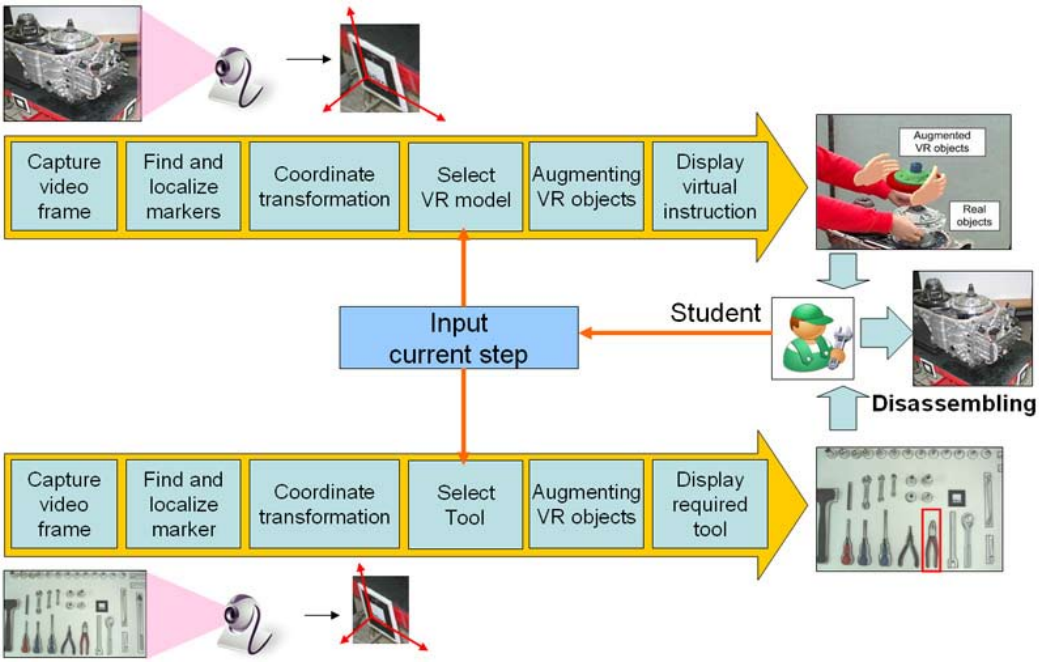


Fig. 6 Virtual mechanical parts are augmented to the real image of the transmission

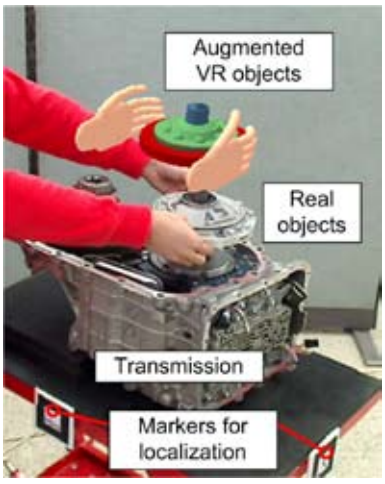


Fig. 7 Indicating required tool with the help of augmented reality.

Application

Proposed educational system can be used in universities, technical colleges and automotive engineering training centres where students study technological process of assembling and disassembling. Recently, developed system is being tested in School of Mechanical Engineering of Korea University of Technology and Education. Courses on automotive engineering compose a large part of the curriculum. That is why this system can be used by many students in their practical classes. In Fig. 8, four steps of disassembling process are shown. Student follows augmented virtual instructions step by step. In Fig. 9, overall view of the system during testing is shown.

Fig. 8 A student during the learning process.

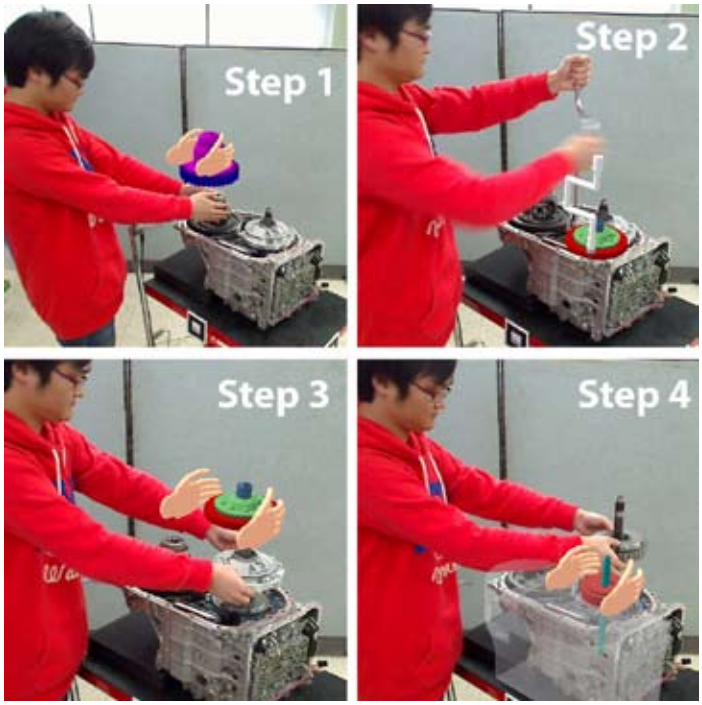
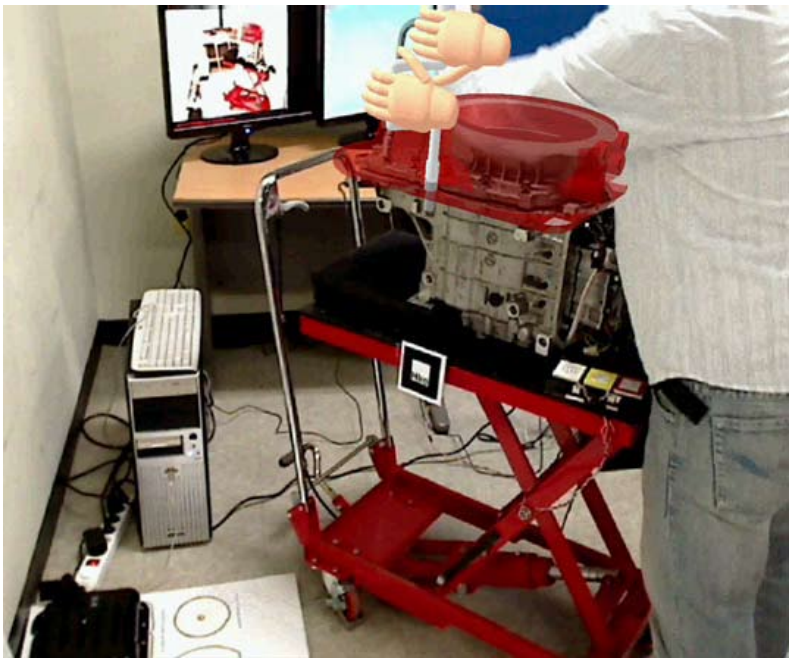


Fig. 9 Overall view of designed augmented reality system.



Conclusion and Future Work

In this paper, development of interactive educational system for automotive engineering is described. Proposed system teaches students how to assemble and disassemble automatic vehicle transmission. System can be used in engineering departments of universities, colleges and automotive training centres.

In future, we plan to extend designed augmented reality system framework for learning other components of the vehicle. For example, vehicle's engine is more important and complicated part. Applying augmented reality based training system will make learning process easier and more interesting.

There are some technical problems which should be solved in future. First, it is important to integrate developed system with CAD-systems. This will speed up the process of developing the virtual training content. Second, adding one more voice interaction channel will improve performance of human-computer interaction. System will be more interactive and intuitive.

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