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Editing 3D models on smart devices

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ABSTRACT

This study proposes a 3D CAD system available on smart devices, which are now a part of everyday life and which are widely applied in various domains, such as education and robot industry. If an engineer has a new idea while traveling or on the move, or in the case of collaboration between more than two engineers, this 3D CAD system allows modeling to be performed in a rapid and simple manner on a smart device. This 3D CAD system uses the common multi-touch gestures associated with smart devices to keep the modeling operations simple and easy for users. However, it is difficult to input the precise geometric information to generate 3D CAD models by such gestures. It is also impractical to provide a full set of modeling operations on a smart device due to hardware limitations. For this reason, the system excludes several complicated modeling operations. This work provides a scheme to regenerate a parametric 3D model on a PC-based CAD system via a *macro-parametrics approach* by transferring the 3D model created on a smart device in an editable form to a PC-based CAD system. If fine editing is needed, the user can perform additional work on a PC after reconstruction. Through the developed system, it is possible to produce a 3D editable model swiftly and simply in the smart device environment, allowing for reduced design time while also facilitating collaboration. This paper discusses the first-ever system design of a 3D CAD system on a smart device, the selection of the modeling operations, the assignment of gestures to these operations, and use of operation modes. This is followed by an introduction of the implementation methods, and finally a demonstration of case studies using a prototype system with examples.

1. Introduction

In recent years, smart devices in the form of smartphones and smart pads have become widely available with the development of networks, the miniaturization of the Central Processing Unit (CPU), and the advancement of mobile technology [1]. Smart devices are equipped with several built-in sensors, including cameras, and allow intuitive inputs via a capacitive touch screen. In addition, wireless networks are available through various paths, such as Wi-Fi, 3G, Long-Term Evolution (LTE) and Bluetooth. The lightweight and portable design makes smart devices ideal for use on the move [2].

Technologies are being extensively developed with the advancement of smart devices. Due to the great convenience and diverse applications offered by these devices, many studies on the application of smart devices to various fields such as industry, defense, and education, are underway. Active investments are also expected as there are numerous opportunities to apply smart devices to industries.

In the field of CAD (Computer-Aided Design), there has been some effort to apply recent technology i.e., smart and ubiquitous technology. It is expected that mobile communications, ubiquitous sensing and computing technology, smart reasoning and agent-based computing, natural interaction techniques and other such technology will play a part in forming the paradigm of next-generation CAD/E systems and environments [3]. Thus, various studies of CAD have been done in recent years. Research in the CAD field includes system architecture studies for human-centered CAD agent systems [4], new CAD interface studies using a brain–computer interface [5], studies that combine CAD and augmented reality environments [6], as well as the digital signal processing studies for networking and sensing [7].

Smart devices also can be a key component of technology for the next generation CAD/E systems. In particular, when engineers use 3D modeling in product design, smart devices can be employed to make 3D models of new design drawings. If an engineer has a new idea while traveling or when on the move, or in the

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	Free-hand 2D sketch modeling	
	Gestural modeling	Reconstructional modeling
Illustration example		
Input property	Procedural	Non-procedural
3D model generation	• Predefined operations • Operation ≈ CAD command	Algorithm
Degree of freedom of modeling	High	Low
Major issues	• Few input strokes • Stroke recognition	• Face identification • Template matching • Z-coordinates calculation

Fig. 1. Sketch-based modeling.

case of collaboration between more than two engineers, smart devices allow modeling to be done in a more rapid, simple, and easy manner. As such, we propose a 3D CAD system for use on smart devices.

1.1. Problem definition

There are many commercial CAD systems for the PC environment, but even the CAD companies behind the creation of such systems have only managed to develop 3D model viewers or cookbook applications in smart devices. Regarding the few CAD modeling applications for smart devices such as *AutoCAD WS*, only 2D modeling is supported. Why does not an application that supports 3D modeling exist? From a developer's perspective, there are several reasons that make it difficult to create CAD modeling programs for smart devices.

The first reason is that most PC-based commercial CAD systems are too heavy. Generally, several convenient functions and engines are built into commercial CAD systems, including graphic engines for the gorgeous rendering of 3D models, leading to a large installation capacity and high computational complexity. Of course, there are several approaches to solving this problem, such as cloud computing or remote control of the network server, but these methods cannot run on a stand-alone device without a network and are thus limited to specific environments in which users have access to the internet.

Second, the input commands of smart devices are mostly limited to touch commands. Recent smart devices have minimal hardware buttons, and the user must touch the screen of the smart device with a finger to choose menus or to operate the device. Commercial CAD systems have numerous functions, implying that using these many functions on a smart device would require a very complex UI, a range of menus, or complex definitions of touch commands.

In addition, it is not easy to perform complex or precise tasks on a smart device due to the small screen and rough position pointing with touch commands. Real industrial models have complex geometries, and accurate scales of each part in units of millimeters or less are needed. Thus, the entire task, including detailed modeling, cannot be done solely on a smart device. Additional, detailed corrective work must be done on a PC environment after finishing the simple and rough work on a smart device. During this process, another problem can occur. The file format of 3D models from the smart device must be readable in the CAD program on the PC. However, the market for smart device applications has been recently dominated by venture-capital companies and private developers. If the developer of a CAD application is a commercial CAD company, the proprietary file format of the commercial CAD can be used for additional work on the PC. However, if this is not the case, the CAD file must be translated (exchanged) to another commercial CAD file or the developer must provide a PC CAD application in order to edit the model. There are several standard formats for exchanging 3D models, but most standard formats such as STEP or IGES do not save the modeling history. Thus, it is difficult to edit 3D models in a commercial CAD system after exchanging. Due to these complex problems, 3D CAD systems for smart devices cannot be easily developed [2].

1.2. Target system

The target of this study is as follows:

1. develop a CAD modeling system for smart devices. Define a subset of modeling functions for creating light smart-device applications.
2. use multi-touch commands as input for CAD modeling. Perform mapping between the functions of the defined subset and multi-touch gestures. Make additional menus and buttons to support gesture inputs.
3. save the modeling procedure in the form of a macro file. The system saves the entire modeling procedure as a file in the ASCII format, which allows users to modify models on a PC.

Through the developed system, it is possible to produce a 3D editable model swiftly and simply in the smart device environment, thus reducing the design time while also facilitating collaboration.

In Section 2, several existing CAD modeling studies involving the use of touch-enabled devices are introduced, and Section 3 describes our method in detail. Section 4 shows the results of the actual implementation of the proposed method.

2. Related work

Smart devices have only recently been developed, but there are many studies on pen gesture inputs (one-point touch) as touch-enabled devices have been around since the 2000s. These concepts fall under the concept of sketch-based modeling. There are several methods of sketch-based modeling; the most efficient among them can vary according to the shape of the target models, the method of user interaction, and depending on several limitations [8]. Sketch-based modeling can be divided into two methods (see Fig. 1); the first is gestural modeling, and the second is reconstructional modeling [9].

Gestural modeling refers to the process of interpreting sequential strokes as specific modeling functions and creating a model by a pre-defined method. Reconstructional modeling is the process of considering an entire set of stroke inputs as a projected image of a 3D model, and creating a model using geometric regeneration technology [9]. From a design perspective, reconstructional modeling is intuitive and effective for sketching ideas. However, the entire set of strokes is interpreted; therefore, it is difficult to recognize complex models correctly and modify a model because the modeling process is not saved. On the other hand, in gestural modeling, the user can understand the modeling process and modify models by repeating the input gestures. Therefore, in this research, we focus on gestural modeling in order to create editable 3D models that can be modified at a later point in time.