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Augmented Reality Interaction Techniques in Education

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By

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Abstract

The goal of this thesis is to implement a 2D marker-based finger (thumb and index together) interaction with midair 3D virtual objects. Moreover, we provide the user a visual feedback upon successful selection of the 3D virtual object. The proposed system supports the three basic canonical manipulations; translation, scaling and rotation. In order to evaluate our system, we conducted a set of case studies to test our proposed approach. In addition, a touch-based case study was conducted to compare the results of our proposed approach and that of the touch-based. Our results were based on the performance (completion) time per each task per each participant in addition to a subjective questionnaire that was answered by the participants after finishing the case studies. Our results showed that although touch-based proved to be easier and faster, the proposed midair finger gesture approach proved to be more fun and engaging. Finally, we introduce an implementation of an educational application for kids for shapes sorting in their correct places. The methodology on which the application is built is an intangible technique were the user (kid) attaches colored stickers (markers) to his/her fingertips and interact with the virtual objects appearing on the mobile device screen.

List of Publications

1. Loubna A. Ibrahim, Taha El-Arif, Doaa Hegazy, Salma Hamdy, “Interaction Techniques in Mobile Augmented Reality: State-of-the-art”, IEEE Seventh International Conference on Intelligent Computing and Information Systems (ICICIS), pp. 424-233, 2015.
2. Loubna A. Ibrahim, Taha Al-Arif, Doaa Hegazy, Salma Hamdy, “Marker-based Finger Gesture Interaction in Mobile Augmented Reality”, in ITHEA International Journal "Information Technologies and Knowledge” (IJ ITK), Jan. 2019.

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List of Abbreviations

2D	Two Dimensional
3D	Three Dimensional
AR	Augmented Reality
CMYK	Cyan, Magenta, Yellow and Key
FPS	Frame Per Second
HCI	Human Computer Interaction
HSV	Hue Saturation Value
MVP	Model View Projection
NDC	Normalized Device Coordinates
NDK	Native Development Kit
PC	Personal Computer
RGB	Red Green Blue
SDK	Software Development Kit
UI	User Interface

Chapter 1

Introduction

1.1. Overview

1.2. Motivation

1.3. Problem Statement

1.4. Proposed Work

1.5. Thesis Organization

Chapter 1. Introduction

1.1. Overview

Over the past years, Augmented Reality (AR) has evolved and one of its evolutions is mobile AR (Figure 1.1). A key point of mobile AR is being reactive, which imposes real-time constraints. Hence, developing and improving interaction methods for AR have gained a wide interest in the past few years with the massive growth of mobile technology. Interaction techniques focus on allowing the users to interact with the emerging virtual object and are considered the basis for having a successful AR system. Interaction techniques offer engagement to the users and let the mobile AR system seem alive.

The interaction techniques can be categorized into tangible and intangible, adopting a classification introduced by Bai H. et al. [1]. Tangible interaction techniques refer to the type of interaction where the user physically touches something, whether a mobile screen (touch-based) or a keypad (device-based) [1]. On the other hand, intangible techniques refer to the systems where the user has no physical connection with the environment, such as midair gestures. Tangible techniques proved to be easier to use and non-stressful compared to the intangible techniques. On the other hand, intangible techniques proved to be more engaging and fun to the users, and closer to the real-world interaction than tangible ones.

Figure 1.1. Mobile AR

One of the intangible techniques is the finger-based gesture interaction. Finger gesture interaction techniques can be either 2D or 3D; hence the virtual object can be transformed in 2D or 3D. They rely on detecting the user's hands and(or) fingers. For fingers detection, finger tips can have markers attached (marker-based) to them or marker less. 3D interaction needs an extra camera to provide the depth; for example, Kinect or Prime Sense to capture the fingers in 3D. While 2D can only rely on the mobile device in-built camera.

There are various applications where this approach is needed; such as games and education. Educational applications let students interact and get engaged in what they learn by making the content visible and interactive. For example, in history, students can interact with historical sites as if it is brought to life. Also, in science like physics and chemistry where everything is invisible; as an example, the molecules and chemical reactions can be visible and interactive. Daqri's application offers the interaction between chemical elements, as shown in Figure 1.2. Besides, story books become more engaging and fun when being interactive. In 2018, authors in [37] presented an application for offering information and experience about the endangered animals in Indonesia through virtual objects of those animals.

Figure 1.2. Applications of interaction in Mobile AR. Daqri's App.

1.2. Motivation

Our motivation is to provide a 2D midair marker-based finger interaction with the 3D virtual objects. Moreover, to provide the user a visual feedback upon interaction with the virtual object; the color of the object's border changes to black upon selection.

1.3. Problem Statement

The interaction with the virtual objects is a challenging and evolving field. Thus, the problem we are targeting in this thesis is to study the different interaction techniques. These techniques are either the tangible (touch-based) or the intangible. The intangible interaction can be either 2D interaction with only the camera of the mobile device or 3D interaction with the aid of a depth camera. In this thesis, we will implement and compare between the tangible (touch-based) technique and the intangible 2D technique. Also, we present how the intangible techniques can be used in educational field in the real-life.

1.4. Proposed Work

Our proposed system is a 2D marker-based finger interaction with 3D virtual objects in midair. The proposed system first, detects the positions of the colored

markers which are captured by the 2D mobile device's camera. Then, specifies the position of the intended virtual object. Hence, there is no need for touch input. Upon the selection of the virtual object by the user's two fingers, the system changes the color of the object to visually feedback the user that the object is selected. The user can manipulate the object by either translating, rotating or scaling it.

In addition, we present an application for this approach in Education. This application resembles the educational game for kids of the real shapes board.

1.5. Thesis Organization

This Thesis is organized as follows. In Chapter 2, a brief overview about Augmented Reality is introduced. Chapter 3 presents the related work by listing some of the previous techniques - tangible and intangible - regarding the interaction between the users and the virtual object on mobile devices. The design and implementation of how our proposed approach works is illustrated in Chapter 4. Chapter 5 discusses the case studies conducted for the purpose of testing the approach as well as the results in terms of completion time and user experience. The educational application is presented in Chapter 6. Finally, the conclusion and directions of future work can be found in Chapter 7.