Chapter 1 **Introduction**

Augmented Reality (AR) is the technology of mixing a real scene to that generated by a computer application. Real time response needed in any AR technology complicates the technology. It uses a combination of image processing techniques, rendering techniques, and tracking options to meet the technology needs. This chapter shows the definition of the AR technology [section 1.1] as well as its history [section 1.2]. The chapter also includes the thesis motivation [section 1.3], problem statement [section 1.4], objective [section 1.5], and the contribution made [section 1.6]. Through the next chapters we will briefly discuss the AR technology components, needs, and the solution architecture. The last part in this chapter tackles the thesis organization [section 1.7].

1.1 Augmented Reality

Augmented Reality (AR) is the technology of adding computer generated information to the real scene [1]. AR left research labs and started to invade the markets in 2009. The main goal of AR is to blur the edge between real and virtual scenes [2]. Unlike virtual reality (VR), AR does not create a simulation of reality. Instead, it takes a real object or space as the foundation and incorporates technologies that add contextual data to deepen a person's understanding of the subject [2]. Great aim for the AR technology is to create the sensation that virtual objects are present in the real world [3]. The widely accepted definition of AR according to Azuma [4] requires the following three characteristics: combinations of real and virtual, interaction in real-time, and registration in 3D. When virtual objects are added to a scene, this is known as visual AR. By definition, AR elements are not visible to the naked eye, so visual AR relies upon some sort of display. This display could be as simple as a computer monitor or a television, or it could be something more advanced—such as a see-through eyepiece on a head-mounted display (HMD) [3]. Choosing the suitable display type, and the suitable tracking technique, is a challenge in creating any AR application. In the following parts of the thesis we will tackle the different display types, and tracking techniques. The primary motivation to develop any AR is to establish a more natural user interface by exposing abstract information properties of the real world or associating it with phenomena encountered within the real world such as space and time. An important part of any AR user interface is 3D interaction. Humans know how to interact with real objects and how to handle and manipulate them. The augmentation of the real world with artificial objects aims to leverage that knowledge and extend it to the artificial information objects [5].

1.2 Augmented Reality History

It all started as a dream to visualize imagination. This idea came to life in 1968. At that year, Ivan Sutherland started to create his Virtual Reality (VR) dream and created what is widely considered to be the first VR system. The Sword of Damocles or "Head – Mounted Three-Dimensional Display" [6] was the invention that triggered the idea of seeing our virtual life in a 3 Dimensional view. Sutherland's system required that the user wear a cumbersome HMD that was so heavy to the extent that it had to be suspended from the ceiling. Hence, the device was named the Sword of Damocles. Figure 1-1 shows the Sutherland Sword of Damocles display. Although that was the first VR achievement, yet he recognized that his interface was limited. Sword of Damocles was a display connected to a digital computer that gave its users a chance to gain familiarity with concepts not realizable in the physical world. He literally called it: "*It is a looking glass into a mathematical wonderland*," as he mentioned in his "Ultimate display" paper [7]. Sutherland continued to work on better systems. At year 1965, Sutherland wrote his paper "The Ultimate Display" which was the first AR system idea or better call it the first AR dream.

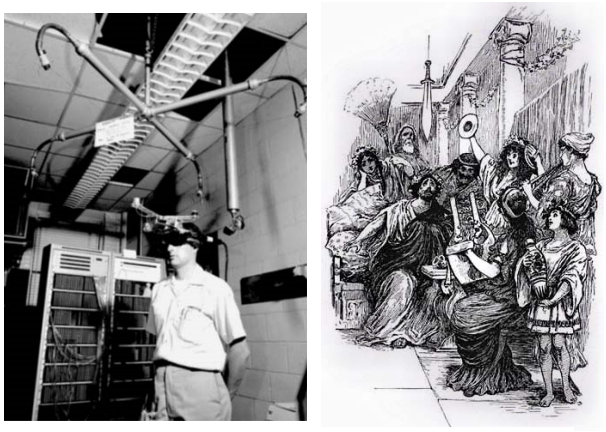

Figure 1-1 Sutherland HMD: Sword of Damocles

"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked." wrote Sutherland, in the Ultimate Display paper [7]

Although the AR technology was first introduced in the 60's by Sutherland, yet only few labs and institutes continued to work on AR researches, as US Air Force, NASA, MIT, N. Carolina University and others. The Boeing joined the researches in the 90's by an AR application used to give construction workers instructions for aircraft assembly

[8]. At the late 90s to early 2000s, AR made several steps towards becoming a widely acceptable branch of computer science.

"We are witnessing the start of the age of augmented reality, electronically enhancing our view of the world. Ultimately we will see augmented reality as the platform that converges the real and virtual worlds and the consequences of that, once fully developed, will dwarf the impact of the World Wide Web."

1.3 Motivation

AR is the field which mixes the virtual scene generated by the computer with the real world, allowing to simulate situations even with the lack of resources, to be a valuable tool for visualization. Our motivation was using the AR technology in the education field, for creating AR labs and using the AR technology to achieve the best performance. One of our main goals is to achieve the best quality and hit the education goal with a fixable solution which is easy to use, develop and encourage students to imagine and invent.

We are also motivated to explore different AR techniques, software libraries, and markers. This could be useful for further researches in this field.

"Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world"[1]. Our hope is to create such a solution using AR so that students can "*Realize"* the "*Imagination"*.

1.4 Problem Statement

In Egypt, 16,101,210[2] students are involved in the basic education grades. Over the past few minutes just as you are reading this, there are 9 new articles that were created on Wikipedia, 10 new books were printed out and published and 3,400 new posts were posted on blogs at this very same moment. The information world is rapidly growing and expanding and our education system should be able to cope with this rapid process.

Our education system limits the information given to students for each subject through one book only although more and more information is available on every topic everywhere. This information can be easily accessed through the Internet. Right now on Amazon.com alone there are 242,287 books on biology, 233,662 on math, 263,442 on geography and 4,262,625 on history. Imagine the amount of data that our students can gather if they can read more than just one book for every subject, how would that add to their knowledge base?

If we consider the technical information, this is not only found in printed books. Such information can be found on blogs, journals, magazines, illustration videos…etc. Such technical information expands with vast steps and doubles every two years. This means that when our students graduate, half the technical information they have been taught and trained on will be out of date! This means that the educational system that exists nowadays is not stable enough to face the rapidly growing knowledge world.

[1] By, Albert Einstein

[2] pre-university education Statistics among the academic year 2009/2010

Gen Y[3], has proved themselves to be high-tech students, open-minded, craving for changes. Gen Y wants education to be "Interactive, Student-centred, Authentic, Collaborative, on-demand". The educational system needs fundamental changes to create a reproductive pool of talents. "Instead of asking them (students) to watch, to listen, to play, to passively consume, the race is on to get them to create, to produce and to participate"[4]. In fact, the traditional ways of educating our students should be changed, "if we teach today as we were taught yesterday, we rob our children of tomorrow"[5].

Education is all about storytelling and visualizing certain images and actions in the students' imagination. The concept of virtual education has been there for thousands of years through books. An author tends to convey certain actions and stories to the students just using his words to create a vivid picture that would provoke students' wild imagination to create a tangible picture of the story. So, the use of virtual reality is as old as human beings but with a different naming. Over the past decades, the education process is the same with different tools, it started with simple printed books, evolved to computers, then internet penetration, VR, AR and who knows where would it stop. "The process is the same but the tools are different…different media…different speeds."

However, the usage of high technology in the education field has always been associated with certain problems that were challenging. Using high-tech made the education process complicated, technology-oriented and missing the entertainment factor, the things which were not appealing to students. This was the case with most of the VR applications used in the education field. However AR is expected to be an effective solution for most of these challenges. "The future is already here, it's just not evenly distributed."[6]

"Sometimes it seems we are having to run ever faster just to stay in the same place "

1.5Thesis Objective

Our thesis objective is to use the benefits of AR technology to improve the education process. Increasing the visualization ability for students, with the minimum tools used, is our motivation for creating the ARSC [Augmented Reality student Card]. ARSC leads to better understanding by increasing the visualization ability. It also supports the edutainment learning techniques by the 3D objects augmentation with real scenes and the ability to connect to extra outsource edutainment lesson materials. Our aim is to use ARSC to add practical, interactive and creative ways to the education process, the thing which is now seriously needed [9] to increase students' creativity and practical skills. We made an analysis on the education learning process, environment, needs and obstacles. Our aim is to study the options of AR tools, libraries, and obstacles to achieve the best approach that can cater to students' needs.

[3] Generation Y, the new technology generation marked by an increased familiarity with comm., media, and digital technologies
[4] By, trendwatching.com
[5] By, John Dewey
[6] By, William Gibson

1.6 Contribution

This thesis presents and explains the usage of AR technology for the education field based on our research aim for creating an educational application using the AR technology

This research introduces Augmented Reality Student Card (ARSC) as an application of AR in the field of education. ARSC uses single static markers combined in one card for assigning different objects, which leads to lesson visualization and decrease the number of markers (package size).

ARSC can represent any lesson in a 3D format that helps students to visualize different learning objects, interact with theories and deal with the information in a totally new, effective, and interactive way. ARSC can be used in offline, online and game applications with seven markers, four of them are used as a joystick game controller.

Connecting all the offline, online, joystick controller, and other ARSC solution by the AIR interface leads to produce easy to use interface with easy upgrading features. ARSC needs no specific hardware installation, only connecting the pc to a webcam can make the ARSC solution works.

The experimental work in this research also shows the constraints for marker creation for an AR application. As we need to work in both online and offline application, merging of toolkits and libraries has been made, and give the ability to render 3D models with multiple texture types and enables the solution to render the non-uniform 3D objects without any shape deformation.

Working with different toolkits that support multi markers recognition, makes ARSC allow for the usage of different markers with no conflict errors thus, allowing multiple cards to work effectively together, as long as the cards are within the camera's view, which decreases the PC working station needed.

The ARSC can be correctly assigned to the markers' base with very limited registration error. This feature allows for the resizing of the virtual objects relatively to marker's size, also giving the ability for free zooming and navigation.

Using a combination of different also toolkits enables the ARSC to work under bad / poor illumination, and within fuzzy working environments.

It was experimentally proven that we can use a card of size 9.5 X 5.5 cm up to a distance 69 cm from the camera lens. Each student only had one ARSC from the beginning of the education trip till the end without any need to change it, hence minimizing the printing costs.

ARSC was examined by a number of students of both genders with average age between 10-17 years. The survey showed that 89% of the students were satisfied by the efficiency of the ARSC. The previous survey also shows the suggestion for the subjects to be used within the ARSC solution. It gives the highest value to “Science and Biology” with 34.7% of the total votes, following by “Art & Design”, “Chemistry", “History” and leaving the lowest value to the “Languages” subjects with 5.1%.