Augmented Reality, an Enabler to Self Organized Learning

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Abstract

From educational pupils in elementary schoolsto post-doctorate candidates to empower the new generation to attain a favorable attitude towards self learning, thinking, and innovation augmented reality (AR) application will provide and instill real value to students as well as educators alike. Schools of all sectors and specializations can utilize augmented reality in the creation of useful and productive tools which make both providers and receivers of education more efficient in their provision and attainment respectively. This work gives an introduction to augmented reality and its application in education, in addition to a demonstration of its usefulness including its application to extending education and educational material exposure to the layer of society with certain sensory impairment.

Keywords: Augmented reality, Google API, Automatic annotation, Object Identification

INTRODUCTION

Augmented Reality (AR) can be simply defined as the superimpositionof objects in 2-D or 3-D, as well as other audio/video materials on a pre-defined segment of reality perceived through a computer input device or stand-alone-embedded device. The reality-Virtuality Continuum is defined by Paul Milgram and Fumio Kishino as a continuum that spreads over real environment and virtual environment where the later comprises Augmented Reality and Augmented Virtuality, AR being closer to our real environment and AV closer to a totally virtual environment [1]. In addition to AR being a technology which augments the sense of our perceived reality through sight, it can also potentially augment end-users missing senses such as the sight of blind end-users via substitution by the use of audio cues, or augmenting hearing for deaf end-users by the substitution of visual cues [2]. Thus AR is a supplement to reality not a reduction, which extends its envelope to a multitude of real world applications for a variety of sectors within industries most notably education.

PEDAGOGICAL BACKGROUND

It has been mentioned in [3] that the most important purpose of an educational environment is the promotion of social interaction among recipients located in the same physical space. However, this type of social interaction is preferred in collaborative settings not in the conventional sense where individualistic self-learning attitude is encouraged. This is further emphasized by Constructivist Theory which pins the position that the transmission of knowledge does not exhibit a direct flow from the knower to the other but by is actively built up by the learner [4]. This brings back the origins of the word Education which means the breeding/the bringing up and raising of knowledge by one’s account where learners are involved directly in an active processwhere new knowledge is constructed on the basis of prior knowledge and experiences.

In the field of Psychology, Cognitive Psychologists Dienes (1964, 1976), and Piaget (1960) had postulated the importance of active student involvement in learning. The mentioned psychologists believe the process of learning to be deeply personal involving the internalization of the concept by the learner [5]. Backed up by such theories, the role of the instructor is to help manifest an environment in which learners can construct, develop, and extend their knowledge [5].

From technology advancement point of view, spinning from our physical world which was dominated by the printed media as a physical object, then digital media on CD-ROM, which then was all hosted by the web to a totally new media designed for the web, we are today at the phase of interaction with the physical world part which is AR era. This technological advancement allows today’s end-users to detect content off printed paper with platforms capable of retrieving associated digital media stored on the web or a local platform. Such advancement enables the emergence of up-to-date content on printed media by virtue of updated online material. This in effect keeps our classrooms and curriculum material in a perfect alignment with the rapidly changing knowledge domain many educational systems find hard to keep up with.

HISTORY

AR goes back as early as 1901 when the author L. Frank Baum first mentioned the idea of an electronic display that overlays data onto real life. However, it was until the late 50’s that Morton Heiling created and patented a

simulator called Sensorama incorporating visuals, sound, vibration, and smell (Fig. 1). Next, Ivan Sutherland invented the head mounted display in 1966. In 1968, Sutheland was the first to create an AR system using an optical see-through head-mounted display (Fig. 2) [6].
In 1975, L.B Rosenberg successfully developed what is cited to be the first functioning AR system by the name of Virtual Fixture demonstrating human performance, while in the same year, the first AR paper called KARMA was presented by Steven Feiner and colleagues [1].

Figure 1: Morton Heiling'sSensorama

In 1989 Jaron Lanier first coined the phrase Virtual Reality and successfully created the first commercial business around virtual worlds. In the following year, at Boeing workers assemble cables into aircrafts, Tom Caudell coined the phrase Augmented Reality [7].

Figure 2: Ivan Sutherland's Head-Mounted Display

In the years to follow, more and more AR applications including Integrated Development Environment (IDE) and Application Programming Interface (API) have been produced with both commercial and open source licensing. Most notably is MIT's 6th sense prototype with the recent spike in mobile and tablet computing power that brings a promise to a revolution in the field of AR.

AUGMENTED REALITY TECHNOLOGIES

AR comprises Input Device; Display; Marker Tracking, and a Computer or Mobile Phone. There are several input devices used in AR; some mobile augmented systems use gloves as primary input [8]. On the other hand, others such as ReachMedia use wristbands [9]. The case of Mobile Phones, the smart phone itself is used as an input device through the utilization of its built-in camera by pointing the device's camera at the area of interest (marker). Many modern AR works on the basis of built-in smart phone cameras, or attached desktop/laptop USB web cam.

Three major displays are used in AR system: Head Mounted Display (HMD); Handheld Display, and Spatial Display. HMD comes as part of a helmet or even more advanced spectacles that are mounted on the head. Such display system can be used in both AR and VR applications. Due to the cost of HMDs, there are often considered to be a luxury item or are in use in industrial settings such as manufacturing and tooling.

Handheld Display are more common place nowadays due to the fact that they come embedded into the handheld device by default, such as smart phones. This type of display uses video-see-through to overlay graphics on captured environment.

Spatial Displays are the least common among all types of AR systems' displays. Such displays use RFID tags, video projectors, or other tracking technologies to project information on a separate physical plane. Such mechanism does not require the use of wearable or handheld devices (**Fig 3 – scan to see the figure**).

Marker Tracking in AR system can be one of six mechanisms: Intertia; Optics; Ultrasonic; GPS; Magnetic Sensing; and Mechanical [10]. Taking mobile smart phones, the tracking device is optic through the use of built-in cameras. This employs visual recognition technology to recognize the pre-defined section of the optically captured environment on which the superimposition of 2-D/3-D or streaming video object is overlaid. Leaving behind the technicalities and mathematics which enable the visual recognition and object superimposition, the following (Fig. 4) describes the steps housed in a typical AR system application.

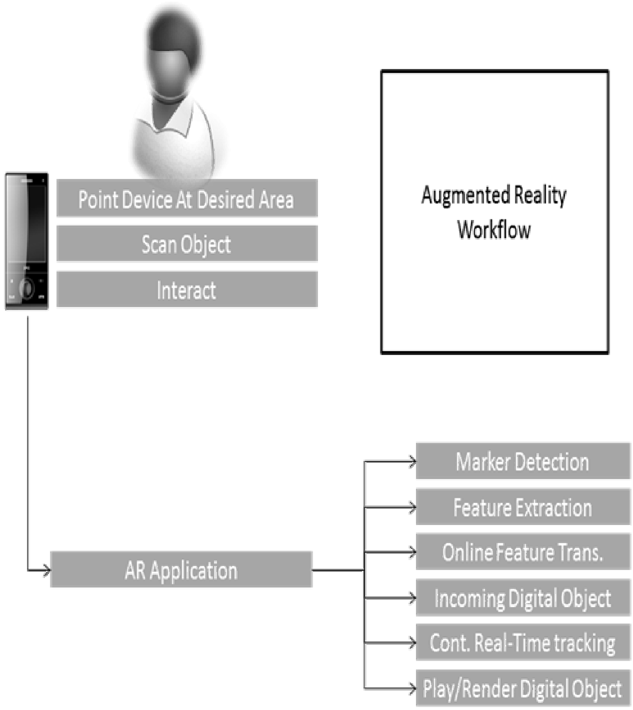

Figure 4: Typical Workflow of AR Smart Phone System

PROPOSED SYSTEM

This work introduces a proof of concept of combination of technologies to bring educational materials from a medium transferrable from the knower to the leaner in a self-organized learning process where students take the ownership of their learning process and put it into successful action. Since this type of learning is considered an informal learning, from pedagogical point of view, it can also be expanded to all sorts of educational materials spanning from research papers, training manuals, books, magazines, newspapers…etc. the proposed system is also designed to bridge the gap between citizens of society with sensory impairment such as blind or deaf persons to benefit from the rapid overflow of information.

The proposed system expands its AR application, rather than combining them, to suit the material and the learner of information. There are two main classes of acquirers considered by the proposed system namely: Self Organized Learners (i.e.; students); and persons with sensory impairment. For self organizing learners, portions of the physical material can be transformed into a lively streaming video; Audio 2-D; 3-D, or slide show objects with content being updated by an authorized party such as the knower or an instructor. The knower or instructor can be substituted with the author of the educational material itself and supplements are added by the knower, subsequently by students in a collaborative manner. For persons with sensory impairment, there are two types of substitution available namely: Audio; and Video. For visually impaired or persons with poor sight an audio substitution cues are added to the educational material; for persons who cannot vocalize intelligibly or suffer from complete deafness, an audio substitution cues are added to the educational material.

To better bring the concept to the audience, this very paper is written and designed with the two classes of end-users in mind. The author has implemented a mechanism for all figures and certain sections to be digitally active when a mobile smart phone camera is pointed at them. The material in this paper, except for the written part of it, can be changed, altered, corrected, and updated at any time from the back-end database without the need to actually change the written content. This ability can be further utilized by taking advantage of Web 2.0 in the generation, organization, and sharing of content.

To benefit from the added digital content to this print media, the following components are required:

- Mobile smart phone with any basic camera.
- Android operating system 4.0 or above.
- Layra client application.

Execute the application from your phone home page or desktop and point the camera at the abstract section for audio cues, figures for video cues, or as directed in some parts of the paper.

The proposed system uses Layar client API and development platform to bring about such liveliness to its material [11]. Layar is one of many applications from spin off companies in an attempt to revolutionize AR systems for mobile phones.

Software Agent to Enhance Augmented Reality

In this paper we introduced an innovative approach to help identifying physical objects observed by augmented reality sensors, the approach is achieved by embedding android based agent that can perceive objects within the scene and use available resources to identify it. Anyway every image captured by sensors can be represented as:

$$I = \sum_{i=1}^{N} C_i . \qquad \text{eq.1}$$

Where

I: Image captured by the sensor

C_i : i^{th} Concept within the image

$\vec{v}_i$: i^{th} Semantic for corresponding Concept

And we have

$$Repository = \sum_{j=1}^{N} C_j . \vec{u}_j \qquad \text{eq.2}$$

Where

$Repository$: Internet web pages

: j^{th} Concept within the Internet web pages

$\vec{u}_j$: j^{th} Semantic for corresponding Concept, semantic is revealed from the annotation that describes corresponding concepts.

Vector projection is given by the following formula:

$$Proj_v u = \frac{u.v}{|v|^2} . \vec{v} \qquad \text{eq.3}$$

Thus we have

$$C_i \equiv C_j \text{ iff } Proj_v u \cong u \qquad \text{eq.4}$$

In our proposal and according to eq.4, we have first to decompose captured image into collection of visual objects, as in algorithm-1, and later on collect knowledge regarding extracted objects by surveying the internet automatically by the Agent.

Algorithm 1: DecomposeImage2Blobs
Input : int blobCount, Bitmap orgImage
Output: List<Bitmap> blobImage

```
Begin
//define blob counter
 BlobCounter blobCounter  = new BlobCounter();
// Initialize blobCounter
          blobCounter.FilterBlobs     = true;
          blobCounter.MinHeight       = 15;
          blobCounter.MinWidth        = 15;
// Process the input Image
          blobCounter.ProcessImage(orgImage);
//  Get blob information  using blob counter
          Blob[] blobs = blobCounter.GetObjectsInformation();
```

```
// Extract Images of each blob
        For each tmpBlob in  blobs
         Begin      blobCounter.ExtractBlobsImage(orgImage,tmpBlob,true);
    Bitmap image = tmpBlob.Image.ToManagedImage();
                 blobImage.add(image);
         End

End
```

After extracting objects from the scene captured by the augmented reality sensors, those objects are sent automatically to Google search engine and related images are retrieved.

Algorithm 2: Retrieve Annotation about images
Input : List<Bitmap> blobImage
Output: SemanticMatrix

```
Begin
  For each bitmap in blobImage
    Begin
       QueryGoogle( bitmap);
       Read Annotation for Images;
      Build Sematic Matrix  ;
    End

End
```

Table -1-
Semantic Matrix From Image Annotations

I_1	I_2	I_3	-----------------	I_n
$anno_1^1$	$anno_1^2$	$anno_1^3$	-----------------	$anno_1^n$
$anno_2^1$	$anno_2^2$	$anno_2^3$	-----------------	$anno_2^n$
| | |	| | |	| | |	| | |	| | |
$anno_m^1$	$anno_m^2$	$anno_m^3$	-----------------	$anno_m^n$

When semantic matrix is constructed, we can move to analyze it using statistical analysis technique such as the SVD (Singular Value Decomposition) to capture the variance in the annotations and eventually capture the candidate annotations for the images captured from the augmented reality sensors, as the following:

$$A = U\Sigma V^T = \sum_{i=1}^{N} \sigma_i u_i v_i^T$$

$$\xrightarrow{\text{yields}} A = \sigma_1 u_1 v_1^T + \sigma_2 u_2 v_2^T + \sigma_3 u_3 v_3^T + \ldots + \sigma_N u_N v_N^T$$

And

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σ_i is the vairance and it is equal to $\sqrt{\lambda}$

Σ is a diagonal matrix of σ_i and reflects the variance of the latent semantic in attributes domain (i.e., words) and the semantic in the documents domain. Despite the fact that SVD comes out to dimensionality reduction, there is another beneficial outcome which is knowledge condensing vectors; this is the vector that results on maximum knowledge about the document.

Common features tend to have less variance over the semantic matrix, thus attributes which are obeying poison distribution

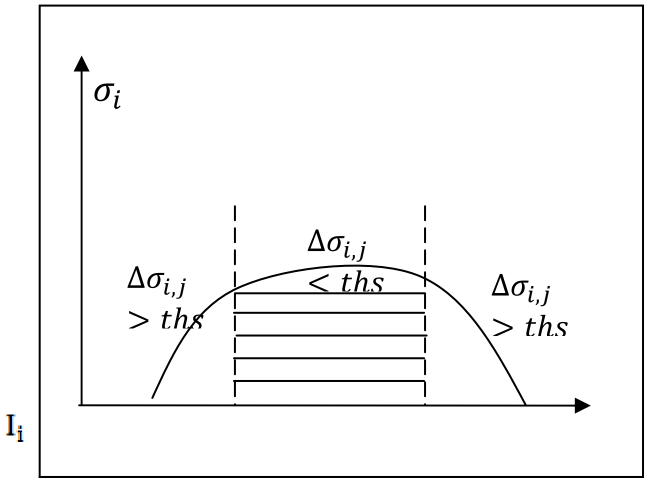

Figure 5: Shaded Area is Used for

in figure (5), 'ths' is a threshold assigned by the programmer to tune up the accuracy of the annotation for images extracted.. figure (6) is an image captured by Galaxy smart phone N7100 note 2.

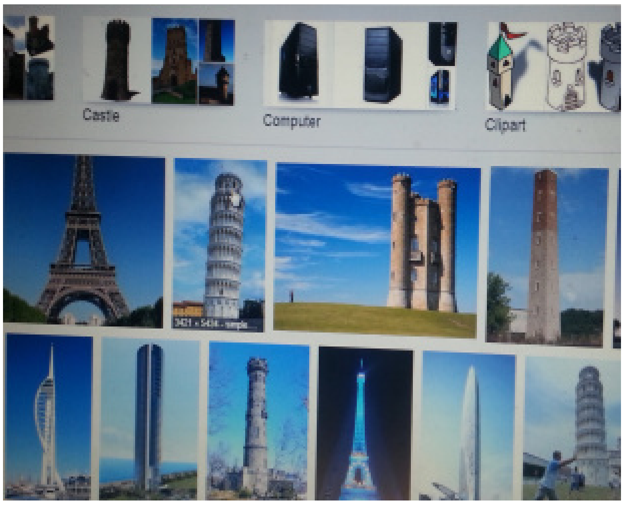

Figure 6: image captured by Android phone

this image has been manipulated automatically by the proposed system and the resultant image is presented in figure (7).

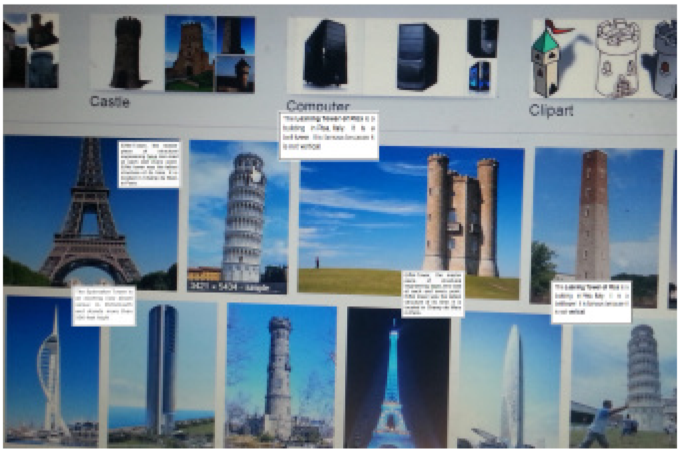

Figure (7): Image has been annotated automatically

CONCLUSIONS

Automatic annotation for images captured by augmented reality devices is a promising approach for self education, where unknown objects within any captured images are defined using rich resources which are the internet repositories.

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