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A Framework for Providing Augmented Reality as a Service Provided by Cloud Computing for E-Learning

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Abstract:
The main objective of the proposed study is to develop an e-learning system using augmented reality technology one of the main problems faces using AR in education is the huge computational power needed to transfer 2D animation to enrich learning facilities. Such problem increases when using smart mobile devices that suffer from hardware limitation. A promising framework is used to utilize cloud services to support augmented reality applications on the cloud. Such method significantly reduces consumption of memory and processing units when dealing with large size videos or images. Hence the augmented reality processing is speeded up to meet the requirements of E-learning systems.
The proposed work was conducted on 100 students from different academic levels in the first semester of the year 2022. Three experiments were conducted for different fields of education including two-dimensional images using Unity Program (3D Software) to draw 3D objects and Vufoira software development kit. The experimental results showed promising results as the application has the flexibility to work on different platforms. Moreover the consumed memory to run the application is reduced significantly. The results also showed high performance for the application when drawing complex 3D images and when dealing with different animations.
The study supported with a detailed questioner that proofs the importance of AR in the field of E-learning.

Keywords: Augmented reality, Cloud computing, Ubiquitous learning,education, e-learning.

I. Introduction

Augmented Reality (AR) is an artificial set of 3D - images, produced by a computer to create a simulated environment that incorporates auditory, visual, haptic, and other types of sensory feedback. Augmented reality technology creates environments that mimic real or imagined experiences that cannot be performed in traditional physical reality. Augmented reality technology can be widely applied in many fields, including educational fields such as: medicine, technology and engineering in its various branches, it could be used in mechanics, architecture, or civil, well as the field of history and geography. The strength of the use of augmented reality in education is that it gives the student the opportunity to learn broader and deal with different experiences that were difficult or impossible to implement through traditional education.

Augmented reality can be applied in various tourism, educational, industrial, and medical fields. Several researches stated the benefits of using AR in the field of education[1-3].

The proposed research focus using augmented reality for e-learning as a service provided via the cloud. The research mainly aims to enhance the performance of blended learning that is considered one of the revolutions of education in the twenty-first century. Blended learning is defined as a combination or mixture of e-learning (online) and traditional physical learning in the classroom. [4-6]. Khan Academy is the best model as a blended learning platform [5]. Figure 1 represents the concept of blended learning.

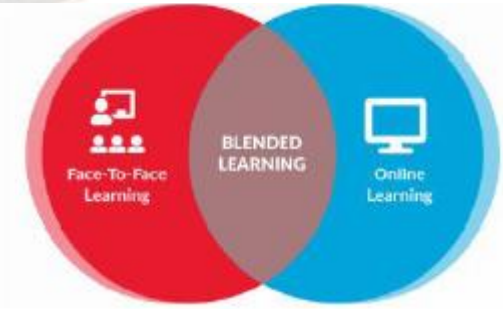

Figure 1.Blended Learning Concept.

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In [7-8],the results of the research that was conducted on augmented reality confirmed that there are still difficulties to rely on AR today compared to other technologies such as educational platforms and multimedia.Moreover, the individual studies in augmented reality technologies were short-term experiments, so the field is still in need of more applied studies to get a higher impact regarding the importance of dealing with augmented reality technology in learning in the future [9]. In [10], Muñoz praised the importance of cooperation between researchers and educators to better progress in this field.

The proposed of using AR in E-learning faces a high resistance regarding the high performance needed when dealing with 3D animation. Such problem rose from the fact that AR applications for E-learning should have the flexibility to run on different platforms including smart phones. Such devices are widely used by students, however it suffer from limitation in computational power. Another limitation that faces AR educational application is the huge number of data associated with moving 3D objects.

The objective of this study is to create a new framework using augmented reality technology as an Ubiquitous Augmented Reality Digital Learning System (UARDLS), The proposed framework provides high accuracy, high performance, and high usability. UARDLS supports education and training programs in different fields that need simulating in different environments. The application gets benefit from using cloud services to store images and data and to get scalable computational power, the experimental results proofed the significant decreases in memory and processor consumption for smart devices. The remaining of the paper is organized as follows. Section two introduces the concept of the using AR in the e-learning field supported with the proposed questionnaire details. Section three represents the literature review, while section four includes the proposed methodology. Section five proposes the experimental results.

II. Augmented Reality Concepts

Augmented Reality is defined as: A form of technology that enhances the real world through computer-generated content. Where augmented reality technology allows the addition of digital content seamlessly to realize the user's perception of the real world.Two-dimensional and three-dimensional shapes can be added, audio and video files and text information can be inserted, and these reinforcements can serve to enhance people's knowledge and understanding of what is going on around them [11].

Khamis in[12], defined the augmented reality as: a three-dimensional technology that integrates between real and virtual reality, that is, between the real object and the virtual object. The interaction with AR is done in real time, while the individual performs the real task, and therefore it is a composite presentation by integrating the real scene with what the user sees and the computer-generated virtual scene, Such proposes enrich the scene with additional information, so the user feels that he is interacting with the real world and not the virtual, with the aim of improving the user's sensory perception. AR applications also get benefit from rapid development in mobile application. Smart phones provides a suitable environment for people to learn in interesting way using AR technologies. However, several smart phone suffer from limited computational power and storage size. On the other hand AR needs huge storage and high computational power to allow transition from 2D images to 3D interacting objects. As a new technology AR lacks frameworks and methodologies that allow using scalable resources such as cloud services.

In order to clarify the urgent importance of using AR in education and the need to enhance its performance a detailed study using questionnaire were applied as follows. The study included 100 male and female students to take the questionnaire from several academic levels, where the results were as follows: 90% agree that augmented reality is suitable for learning compared to traditional methods, and 98% agree that the augmented reality apps in education is cheaper than traditional learning methods, while 88% said that Augmented reality app interaction look real, 99% and higher in this survey. Other said Augmented reality app is faster and more accurate than a classic classroom, 95% agree AR doesn’t require special tools, 97% agree the possibility of error in app Augmented reality is minimal, 20% agree with augmented reality application in education that enables interaction between students, 70% agree that an augmented reality application needs a high resolution of the camera to render images, and 93% agree that the cloud is used in augmented reality application which is powerful to reduce memory and computation processing and 88% agree that augmented reality can be applied in any field. The researcher’s conclusions from the study found that the proposed e-learning service for cloud computing is useful in the field of education, where two-dimensional images are simulated to give three-dimensional images that simulate the real environment with high-resolution standards and low memory usage of device and processors. Students can learn at any time with a mobile phone or virtual reality glasses.

III. Literature Review

AR technique has a significant impact on performance and improvements of the learning process in addition to the various advantages of real-world annotation, contextual visualization, and visual tactile visualization. [13].Applying

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augmented reality technology in teaching classroom curricula resulted in enhancing concepts for students much better than traditional education, it help in developing ideas and exploration skills and increasing knowledge, which in turn enriches information and educates students well, Such education enhancement is required to create a rising generation, educated and capable of development and innovation. In [14],researchers categorized a number of educational games in their various forms. Through the experiment, they understood the importance and practical impact that learning by experience adds through simulating the external environment. The recommended relying on augmented reality technology to improve education process. [15]. Moderately, according to studies, it is possible to have cooperation in the use of augmented reality technology to enhance and enrich the education of people with special needs taking into account the data, its security, and the challenges of technical support [16].Web AR is one of the best events that took place in the technological field, and it is considered an excellent breakthrough in the field of augmented reality technology, for several advantages: The fifth generation networks provide multi-access computing and device-to-device communication, all of which are considered a prelude to successful infrastructures in the development of augmented reality using web AR.[22] One of the challenges faced by researchers in the field of augmented reality technology is response time, tracking, and device failure autonomy. Research has concluded that vision-based methods must be combined with sensors to get a result closer to real reality. Augmented consciousness techniques.[23] Through the research conducted by Ricardo Palmarin and his colleagues, on the extent of development resulting from the use of augmented reality technologies in the fields of industry, and the research resulted that these areas are still far and complex towards augmented reality technologies, which requires researchers to make efforts to extract research and enhance augmented reality in the industrial field and its applications [24] Augmented reality has been listed as one of the top ten technologies by authoritative organizations such as The American Times Weekly. It predicts further development, scientific research, and practical application of augmented reality technologies increasingly because of its effective touches in the interaction between man and machine and the experience experienced by the end user, as it has become easy for users in various fields to accept new technologies that contribute to enhancing their skills and experiences, so there is an investment High in augmented reality applications, and an increasing activity is expected annually. [25]The researcher, Stalianos and his colleagues, highlighted the need to develop the use of augmented reality technologies in enhancing STEM learning..[26]. It is very important when developing augmented reality applications, taking into account the requirements of the latest user, through the role played by the use of augmented reality technology and virtual reality in education for history or in museums and historical headquarters, where the user was able to live the historical event and interact with him about the documentary films that are considered Its role is somewhat limited to modern technology, which requires motivating teachers to pay attention to technologies that depend on the augmented and virtual reality that greatly enriches the education process for the student and the teacher, and enables them to live a different and very rich educational experience. [27].

IV. Methodology

This study aim to develop a framework that provides augmented reality as a service provided by cloud computing for e-learning. Augmented reality can be applied in various educational fields. For example, Figure 2 and Figure 3 show how the use of augmented reality that simulates the external environment such as text, textbooks or objects it also includes models that enhance visual and sensory nutrition in education, such as the AR Anatomy application that targets medical students and helps them memorize organs and help students with education.

As previously discussed, the system is delivered to students as mobile application that takes advantage of the capabilities of augmented reality technology in e-learning . The framework gets benefit from scalable computational power and storage offered by cloud computing. The provides ability of dealing with evidence and the possibility of learning anytime and anywhere. Other applications that work with augmented reality technology in the field of education suffer from difficulties in use andcomplexity, Especially the first primary classrooms, which makes them not well suited to students

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Figure 2. AR Anatomy app is used to help medical students memorize organs.

Figure 3.AR in education.

The proposed application through this study allows users to study in a more interactive way and expand to understand the media that results from the program in the form of three-dimensional media and features that provide a full explanation of the resulting shape. The basic requirement of the resulting application is a mobile that supports the Android operating system only, or if some users prefer to improve the experience, they can add the use of virtual reality glasses. The proposed program can be dealt with and used by all levels of study (schools / universities / trainee centers), Figure (4) shows, how the proposed framework works

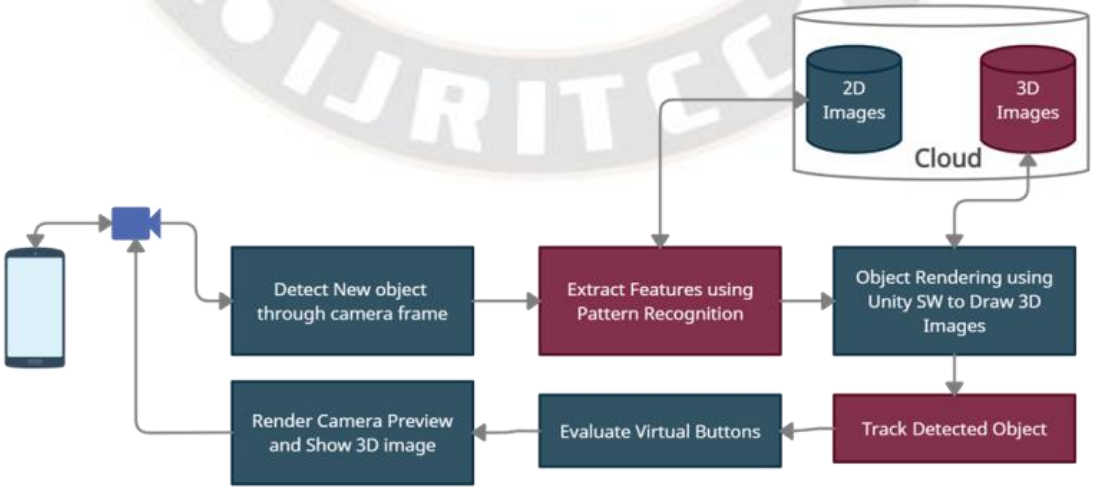

Figure 4. Proposed Framework

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4.1 Framework design

A set of learning objects images are stored in the cloud using AWS storage using Amazon Elastic file system (EFS). The criteria behind using EFS is its server less features, thus the management of data is offloaded from developers to the cloud provider. EFS is also scalable which allows best payment strategies especially when using large size of stored data. For each 2D image is mapped to 3D animation object that is processed just in time of request using Server less features.

The proposed framework starts by user who takes an image for the learning object by his phone camera. The image is passed to a pattern recognition code which extracts the features of the image and enhances its resolution. Then the image is passed to the cloud storage to find its equivalent 3D object. The uploading of the 3D image triggers the 3D object mapped with the 2D image. Then, the 3D animation that is developed using unity starts rendering the mapped 3D object. The 3D animation with its virtual environment is passed to the user to start the learning session.

4.2 programming interfaces:

```
using UnityEngine;
using Vuforia;

public class SimpleCloudRecoEventHandler : MonoBehaviour
{
    private CloudRecoBehaviour mCloudRecoBehaviour;
    private bool mIsScanning = false;
    private string mTargetMetadata = "";

    // Register cloud reco callbacks
    void Awake()
    {
        mCloudRecoBehaviour = GetComponent<CloudRecoBehaviour>();
        mCloudRecoBehaviour.RegisterOnInitializedEventHandler(OnInitialized);
        mCloudRecoBehaviour.RegisterOnInitErrorEventHandler(OnInitError);
        mCloudRecoBehaviour.RegisterOnUpdateErrorEventHandler(OnUpdateError);
        mCloudRecoBehaviour.RegisterOnStateChangedEventHandler(OnStateChanged);
        mCloudRecoBehaviour.RegisterOnNewSearchResultEventHandler(OnNewSearchResult);
    }
    //Unregister cloud reco callbacks when the handler is destroyed
    void OnDestroy()
    {
        mCloudRecoBehaviour.UnregisterOnInitializedEventHandler(OnInitialized);
        mCloudRecoBehaviour.UnregisterOnInitErrorEventHandler(OnInitError);
        mCloudRecoBehaviour.UnregisterOnUpdateErrorEventHandler(OnUpdateError);
        mCloudRecoBehaviour.UnregisterOnStateChangedEventHandler(OnStateChanged);
        mCloudRecoBehaviour.UnregisterOnNewSearchResultEventHandler(OnNewSearchResult);
    }
}
```

Figure 5.The RegisterEventHandlers interface

```
public void OnInitialized(TargetFinder targetFinder) {
        Debug.Log ("Cloud Reco initialized");
    }
    public void OnInitError(TargetFinder.InitState initError) {
        Debug.Log ("Cloud Reco init error " + initError.ToString());
    }
    public void OnUpdateError(TargetFinder.UpdateState updateError) {
        Debug.Log ("Cloud Reco update error " + updateError.ToString());
    }
```

Figure 6.initializing, error screen

```
public void OnStateChanged(bool scanning) {
  mIsScanning = scanning;
      if (scanning)
      {
      // clear all known trackables
      var tracker = TrackerManager.Instance.GetTracker<ObjectTracker>();
      tracker.GetTargetFinder<ImageTargetFinder>().ClearTrackables(false);
      }
  }
```

Figure 7.OnStateChanged() function

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```
public void OnNewSearchResult(TargetFinder.TargetSearchResult targetSearchResult) {
TargetFinder.CloudRecoSearchResult cloudRecoSearchResult =
    (TargetFinder.CloudRecoSearchResult)targetSearchResult;
mTargetMetadata = cloudRecoSearchResult.MetaData;
mCloudRecoBehaviour.CloudRecoEnabled = false;
}
```

Figure 8.OnNewSearchResult() function

```
void OnGUI() {
    // Display current 'scanning' status
    GUI.Box (new Rect(100,100,200,50), mIsScanning ? "Scanning" : "Not scanning");
    // Display metadata of latest detected cloud-target
    GUI.Box (new Rect(100,200,200,50), "Metadata: " + mTargetMetadata);
    // If not scanning, show button
    // so that user can restart cloud scanning
    if (!mIsScanning) {
        if (GUI.Button(new Rect(100,300,200,50), "Restart Scanning")) {
        // Restart TargetFinder
        mCloudRecoBehaviour.CloudRecoEnabled = true;
        }
    }
}
```

Figure 9.OnGUI() function

4.3 3D augmentation objects:

Code to instantiates an ImageTarget that corresponds to the one detected by the Cloud Recognition engine:

```
// Build augmentation based on target
    if (ImageTargetTemplate) {
        // enable the new result with the same ImageTargetBehaviour:
        ObjectTracker tracker = TrackerManager.Instance.GetTracker<ObjectTracker>();
        tracker.GetTargetFinder<ImageTargetFinder>().EnableTracking(targetSearchResult, ImageTargetTemplate.
    }
```

Figure 10. ImageTarget

Initializing the system

```
Vuforia::TargetFinder* finder;
const char* const kAccessKey = "Insert access key here";
const char* const kSecretKey = "Insert secret key here";
onApplicationInit()
{
 Vuforia::TargetFinder* targetFinder = objectTracker->getTargetFinder
    assert(targetFinder != NULL);
    if (targetFinder->startInit(kAccessKey, kSecretKey))
    {
        targetFinder->waitUntilInitFinished();
    }
}
onApplicationDeinit()
{
    targetFinder->deinit());
}
Vuforia::TargetFinder* finder;
onApplicationResume()
{
    finder->startRecognition();
}
onApplicationPause()
{
    finder->stop();
}
```

Figure11. initialize system

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```
Vuforia::TargetFinder* finder;

void MyVuforia_OnUpdate()
{
    // Check if there are new results available:

    TargetFinderQueryResult queryResults =
    finder->updateQueryResults();
    if (queryResults.status ==
    Vuforia::TargetFinder::UPDATE_RESULTS_AVAILABLE)
    {
        // Iterate through the new results:
        for (const Vuforia::TargetSearchResult*
         result: queryResults.results) {
        {
         const Vuforia::CloudRecoSearchResult*
         cloudRecoResult = static_cast<const
            Vuforia::CloudRecoSearchResult*>(result);
            // Get the target metadata
            const char* metadata = cloudRecoResult->getMetaData();

            // Check if this target is suitable for tracking:
            if (cloudRecoResult->getTrackingRating() > 0)
            {
                // Enable this target for tracking:
                finder->enableTracking(cloudRecoResult);
            }
        }
    }
}
```

Figure 12.handling with search results

4.4 Proposed system interfaces

Figure 13. Motors

Figure 14. Heart

Figure 15.application main screen

4.5 Software development tool used:

- **Unity Program (3D Software):**

Unity Programis a multi-platform game engine developed by Unity Technologies [17].

Figure 16.unity

- **Open CV tool for object detection and extract object features:**

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. [18].

Figure 17.Open cv

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- **C# programming language used to compare the 2D image with the created 3D object:**

C# programming language is a general-purpose, high-level multi-paradigm programming language. [19]

Figure 18.c#

- **Vufoira SDK**

Vuforia is an augmented reality software development kit (SDK) for mobile devices that enables the creation of augmented reality applications. Objects are stored in the cloud to decrease the high usage of device, memory, and processor.

Figure 19.Vuforiasdk

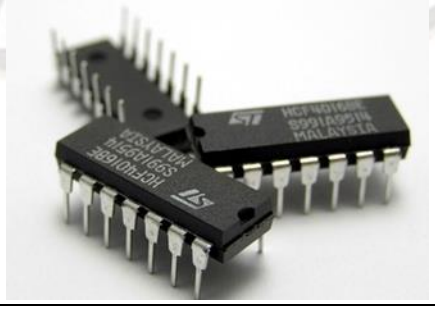
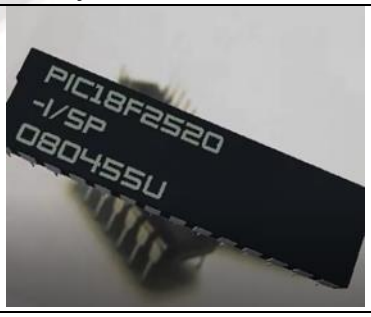
V. Experimental evaluation and results

The 21th century has been known as the era of the industrial revolution and globalization, and the global crisis created by Covid-19 from the year 2020 and the impact is still remaining, which has increased the interest in e-learning. The technological culture has increased among student teachers, which helped to absorb the various digital models, tools and innovations that work to develop the e-learning, the outputs of the proposed work study is a mobile application that supports augmented reality technology targeting the educational sector. The 2D imagesare stored in the cloud and the necessary steps are taken to produce the final shape of a 3D object. Three experiments were conducted for different levels of study in the Kingdom of Saudi Arabia. The participants were a hundred students, and the three experiments were high enough precision, with the time of 3D objects displayed in seconds.

Experiments were used to evaluate how well the application was at distinguishing patterns and to compare feature matching between the 2D image and the 3D image of the object. The 2D images are stored in the cloud, and upon execution, the camera takes the image of the object and then a new 3D object is created, the features are extracted using a computer vision tool, and when this is confirmed, finally, a 3D object is drawn.

The following table (1) summarizes the best performance of the proposed framework for providing augmented reality as a service provided by cloud computing for e-learning. The features for each image, the percentage of resolution and time taken to draw a 3D object in seconds, and the storage space of the 3D object in megabytes were extracted. The experements showed promising results as the application works on any device and does not consume memory as it is stored in the cloud and the time it takes for the application to draw the 3D object is quite workable for the student and the teacher.

Table (1): Table of experiments:

	2D Object	3D Object
Experiment _1		

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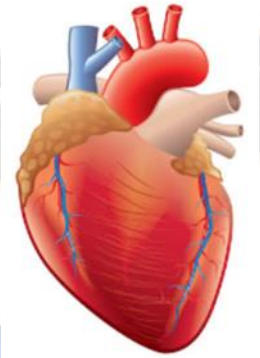
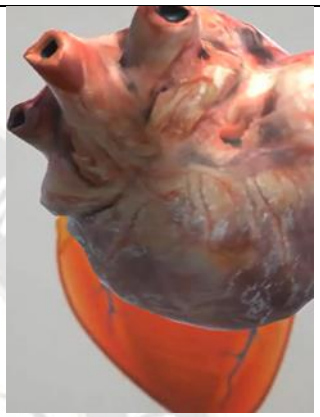
Experiment _2		
Experiment_ 3		

Table (2): performance of the proposed augmented reality application for e-learning with cloud computing:

	# Features	Accuracy (%)	Rendering time (sec)	Storage (MB)
Experiment 1	240	94.8	10	20
Experiment 2	930	96.9	19	33
Experiment 3	580	99.2	14	28

5.1 Supporting questionnaire results:

The questionnaire results were as follows 90% agree with the suitability of Augmented reality for learning than traditional methods, 98% agree with that augmented reality application in education are cheaper than traditional learning methods. 88% said Augmented Reality application interaction feels real. 99% and its highest percent in this questionnaire than other said Augmented Reality application is fast and more accurate than classical classroom. 95% agree with that Augmented Reality application does not require special tools, 97% agree with the possibility of error in Augmented Reality application is small. 20% agree with that Augmented Reality applications in education enables interactions between students, 70% agree with Augmented Reality application need high camera resolution to render images , 93% agree with Cloud usage in Augmented Reality application is powerful to reduce memory and processing consumption and 88% agree with Augmented Reality application can be used in any fields. Table 4 presents the questioner results

Table (3): questionnaire results:

#Q	Questions	# Agrees	# Neutral	#Disagrees
1	AR application more suitable for learning than traditional methods	90	2	8
2	AR application in education cheaper than traditional learning methods	98	0	2
3	AR application interaction feels real.	88	10	2
4	AR application is fast and more accurate than classical classroom	99	0	1
5	AR application does not require special tools	95	2	3
6	The possibility of error in AR application is small	97	0	3

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7	AR application in education enables interactions between students	20	20	60
8	AR application need high camera resolution to render images	70	5	25
9	Cloud usage in AR application is powerful to reduce memory and processing consumption	93	5	2
10	AR application can be used in any fields	88	2	10

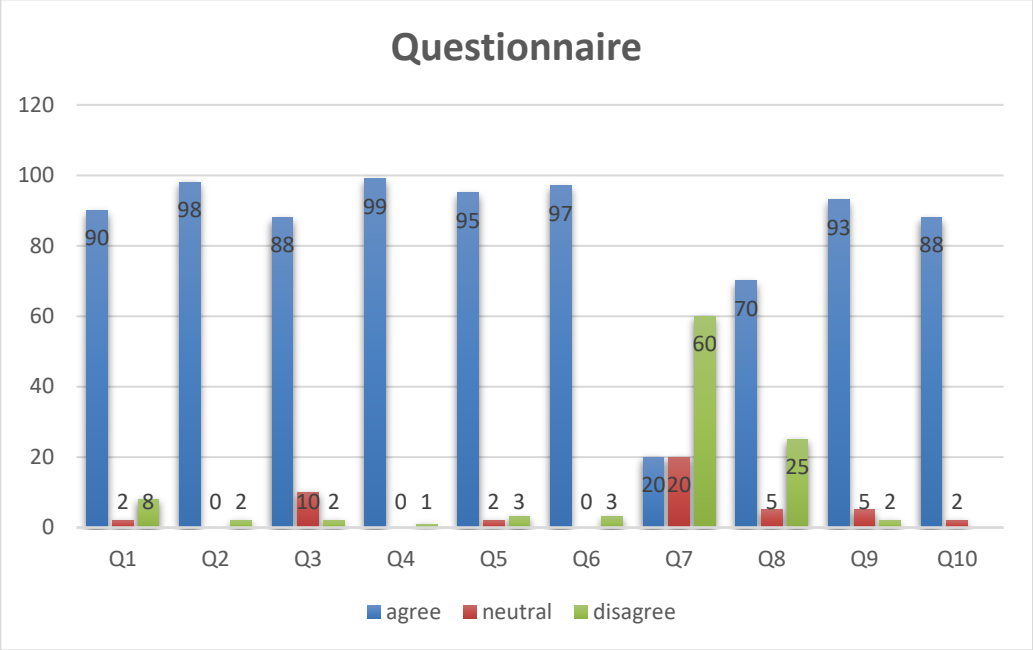

Figure 20.questionnaire results

VI. Contributions and Benefits

The first benefit regarding the use of AR in the educational field is using Ubiquitous Augmented Reality Digital Learning System (UARDLS), which are accessible learning materials: anytime, anywhere.

Another important benefit there is no equipment is required. The system requires can run using students smart phone while using the computational power from cloud providers. The proposed learning system helps in improvement of collaboration capabilities by using practical learning.

Thus the proposed presents a fast and accurate system. Which is applicable to be used by universally applicable to any level of education and training.

VII. Conclusion

In this work apromising framework is proposed for providing the augmented reality technology as a service that can be provided by cloud computing for e-learning. Students are able to use the system anytime and by different platforms. Theframework allow storing huge learning materials for different study levels. The research develops an application that supports augmented reality technology, which works to enrich the education process and improve performance. The first version of the initial augmented reality education program has been completed. The futurework,includes enhancement of the current version by adding advanced security aspects while dealing with the application.

VIII. Declaration

Table (5): declarations:

Ethics approval	“Not applicable”.
Competing interests	"The author declare that they have no competing interests".
Funding	The only source of funding is in my own funding in this version.
Authors' contributions	Rashid Al-jammaz, the major contributor in writing the manuscript.
Availability of data and materials	“not applicable”.

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