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An augmented reality application for localization and classification of glioma in human brain using color-coding

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***Abstract*---**Biomedical imaging involves the complex chain of acquiring, processing, and visualizing structural or functional images of living objects or systems, including extraction and processing of image-related information. Medical imaging is truly a vital element of the healthcare world–an essential tool for physicians to assist with diagnostics, treatment, and prevention. Imaging can provide uniquely valuable information about tissue composition, morphology and function, as well as quantitative descriptions of many fundamental biological processes. The main benefit of medical image processing is that it allows for in-depth, but non-invasive exploration of internal anatomy. Brain tumors are the most common and aggressive disease, leading to a very short life expectancy in their highest grade. Thus, treatment planning is a key stage to improve the quality of life of patients. Artificial intelligence (AI) developments have created opportunities for human life in a wide range of industries, business, education, and healthcare [1,2].The main aim of the project is to provide an environment where doctors can view and interact with patient specific anatomical form. Augmented Reality (AR) is proven to be a right adaptive assist to the medical professionals disposed at their level of capabilities to rightly detect and diagnose the problem and provide suitable solutions with the aid of smart technologies built on the cell phone which would ideally be the right choice as it can capture the real-time data and support the analytics of these records of patients obtained in developing a faster applications with precise measurements. AR adds immense value to the students and professionals learning curve inclined towards medical education and

practise since it allows these trainees to completely portray and envisage the existing problems and the repercussions faced in an ideal manner.

***Keywords*---**artificial intelligence, medical imaging, glioma, image classification, augmented reality.

Introduction

The 21st century has given rise to many technologies that has created impact in the field of gaming, education, healthcare etc. The important deliverable that any healthcare division has to keep in mind is the improvement in the patient's health wellbeing by containing costs. The healthcare sector investments in global markets claim to have huge investments in coming years to increase the life expectancy of the patients. Nevertheless, it is noticed that the rapid growth in the technology has revealed the strength of information which otherwise would be a difference between the patients and the physicians. However, with the advent in the smart phone and the information technologies, the day is not too far, where the physicians shall spend their quality time with the needy patients and leave the rest to be handled either virtually or with a blend of semi-autonomous instincts. Thus if this dream has to come true then the digitization needs to be implemented in full swing. In fact, of about 25000 mobile applications were available in the market from 2017[6] almost incremental every year by a factor of 25%. Unfortunately, digitization of information alone is insufficient to achieve the targets due to huge veracity of data collected by various digital devices as against the conventional data collection from the patients through medical records manually. Thus smart technologies need to join hand with the electronic medical records and support the physicians in identifying the right needy patient who needs the real assistance, care, and address the rest virtually [7]. This right mixture of intelligence such as artificial intelligence, machine learning etc, with the analytical tools for data management allow us to develop new service models to meet the latest challenges in the virtual domain. Augmented reality is one such attempt made here to support the physicians in making right decisions in diagnosing the presence of Glioma in human brain.

Overview

Over the years, it has been observed that the there has been a considerable development in the smart technologies [8] which with the right mix of information have been able to make decisions appropriately. Thus, in the field of medical domain as well, there is a need of developing such smart applications that cater to the need of the physicians in rightly diagnosing the presence of Glioma in human brain. One such attempt has been made in this work by using augmented reality as an assistive aid to identify the presence of Glioma in the human brain and classifying it as a malignant or benign one.

However, from the figure below it is substantial to note the significant contribution of the intelligent systems on the available digitized information has made an noticeable impact in the field of medical diagnosis. It is very convincing

to note that various industries have already affixed the intelligence factor to the systems where as medical domain is still cribbing to adopt the same. Thus, this work attempts to introduce this factor by using augmented reality keeping in mind the 3 components that need to be addressed in the healthcare application development.

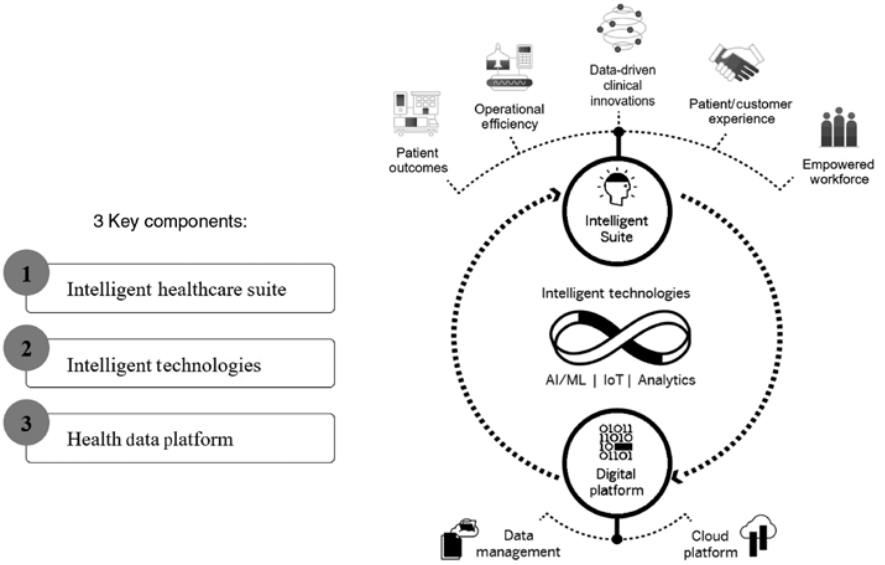

Fig 1. The Intelligent Healthcare Enterprise framework

Augmented reality and its types

Although augmented reality has been applied extensively in the field of education, entertainment and other smart applications, time has been not vary to experiment the same in the field of medical domain and healthcare. One such attempt is made in this paper to promote digitization with intelligence for medical diagnosis. Augmented Reality (AR) is one such attempt that is been implemented here wherein the actual information that is available digitally has been deployed in the real environment using the technology. However, there are 3 components of augmented reality [9] listed as below:

- Integration
- Interaction
- 3D Registration

However lot of work has been carried out in the yester years to integrate the traditional methods with the virtual reality using AR technology in various fields such as medical education, clinical decision making, long time memory retention, gaming, e-learning etc..

Types of augmented reality [1]

- Marker-Based AR: In this technique, as the name suggests, some marking reference needs to be used to transfer the digital knowledge onto

the real world environment. These markers are often made up of some unique patterns that are set as anchors in this technique. However, in the physical world representation, this is the recognized content which is required to be placed on the top of the application.

- Markerless AR: In this technique, the focus is thrown on the adaptability of the target. However Marker-less AR adheres to this principle by selecting the right place to put the virtual object onto. Thus this technique allows the user to try other styles without disturbing the surroundings. Also note that this technique requires few core components to capture and distribute the information available for implementation.
- Location-based AR: This technique is responsible for binding the digital content and the experience to the user's location which shall function once the preset location is mapped with the object that is under observation.
- Superimposition AR: Superimposition AR concentrates on identifying the object that is participating in the present environment and aims at providing a form which may be formed by altering a portion or the whole object.
- Projection Based AR: This technique is quite different from all that existing AR techniques discussed above since for hosting this technique we really do not need any smart device. However, to project the digital information onto any available object, the optical medium is a necessity.
- Outlining AR: This technique is suitable in situations where the human eye fails to track the object boundary. In this approach the object identification is the key point of view to work with considering the present environment around.

Targets

With target tracking [2] world effects, an augmented reality effect is triggered when the camera is pointed at a specific real world target, like a business card or picture.

Types of targets

- Image Target: Image Targets represent images that Vuforia Engine can detect and track. The Engine detects and tracks the image by comparing extracted natural features from the camera image against a known target resource database.
- Multi Target: It is generally termed as a warehouse of many such targets affixed together to generate a concrete geometric structure which shall cater to multiple cases.
- Cylindrical Target: This type of target is focused to track only those images which take a cone or a cylinder shape only with unique labels which cater to the needs of the customer delivering the required customer experience using augmented reality.
- Model Target: These targets are developed when the need arises to identify specific objects based on the morphological structure of the object. This

target involves any real time device, geographical landmarks etc including house hold devices.

Bottlenecks in the AR technology implementation

- Cost: Firstly, this technology requires specially designed devices like HMD, which demands a considerable investment to implement such technology. Secondly, only skilled developers working from long time in this field can develop the design of the technology. This pushes up the cost of the product. However, as mobile phone penetration has increased exponentially, the first reason is not of much importance anymore.
- Budget for Healthcare: In many of the hospitals and Medical colleges, decision-makers are not ready to spend the required amount. The reason could be not enough awareness about the product and technology. They are not able to map the return for their investment.
- Infrastructure: Hospitals and Colleges lack the required infrastructure for the installation of technology until now. However, as the technology is advancing in every aspect and people have started carrying their devices to learn digitally, there is a hope to this problem.

Literature review

In [4] Asma and et.al have proposed a deep learning technique for classification of tumor in human brain on the BR35H dataset. In this work, the authors have used 28% of the available dataset for training and validation, and the remaining 72% for testing. This models average performance was recorded as 98.81% considering the two datasets of the six available in BR35H. In future, the results can be enhanced using CNN-based Computer Assistance Detection system with the support of augmented reality approach.

In [5] Morteza and et.al have carried out the experiment on TCGA dataset retrieved from The Cancer Imaging Archive repositories where grade IV and FLAIR T-2 weighted MR images are considered of 256X256 resolution. About 19,200 and 14,800 sliced images consisting of lesion and not consisting of lesion respectively were captured and supplied for training. This work aimed at localization of the tumor in human brain using the reputed explainable algorithm of AI domain. It is very evident from the results that this kind of architecture contributes significantly in choosing the right training approach for clinical diagnosis.

In [3] Kai and et.al the author throws light on the need of computer assistive technologies such as augmented reality for analysis, detection and prediction of chronic wounds using AR enabled smart glass. The author has claimed that a 2 × 2 research specific designed framework is capable enough to classify developments in research arena into the multiple sections involving invention and design But one drawback of this smart glass is the low maturity level of it. In [6] Emrah Imarak focusses on multi-classification of the brain tumors using publicly available datasets.

The work is carried out on different data sets such as RIDER, REMBRANDT, TCGA-LGG, which consisted of T-1, T-2 weighted and FLAIR images for about 233

patients. This model has outperformed others with an accuracy level of 92.66%. However, with respect to grading of the tumor to its level, the model was able to achieve an accuracy level of 98.14%. The metrics like ROC, F-measure were used for measuring the performance of the model.

In [7] P.Vavra and et.al suggested introduction of augmented reality (AR)—a fusion of projected computer-generated (CG) images and real environment in diagnosis of tumor. In the work carried out, Haouchine et al. has come up with a new defined model which works on the concept of registration considering all the factors responsible for deformation which is likely to adverse the human-computer interface, developed in tandem with surgeons, to yield better results.

Methodology

A suggestive computer assisted automated tool developed would definitely ease out the role of the physicians involved in diagnosis who could otherwise give more attention to the community which needs a dedicated service and monitoring. In this regard, the work focuses on developing one such methodology to overcome the challenges of conventional approach of medical diagnosis through this proposed system with the help of augmented reality.

Proposed Methodology

The proposed solution is to take an input MRI images as input and use Marker Based AR to display the 3D Brain Model with color-coding. The proposed methodology represented in Fig 3 focuses on the application of augmented reality as a form of intelligence on the available medical data of MRI of human brain on which the localization of the presence of the tumor is performed and the classification has been carried out to rightly diagnose the presence of the Glioma in human brain.

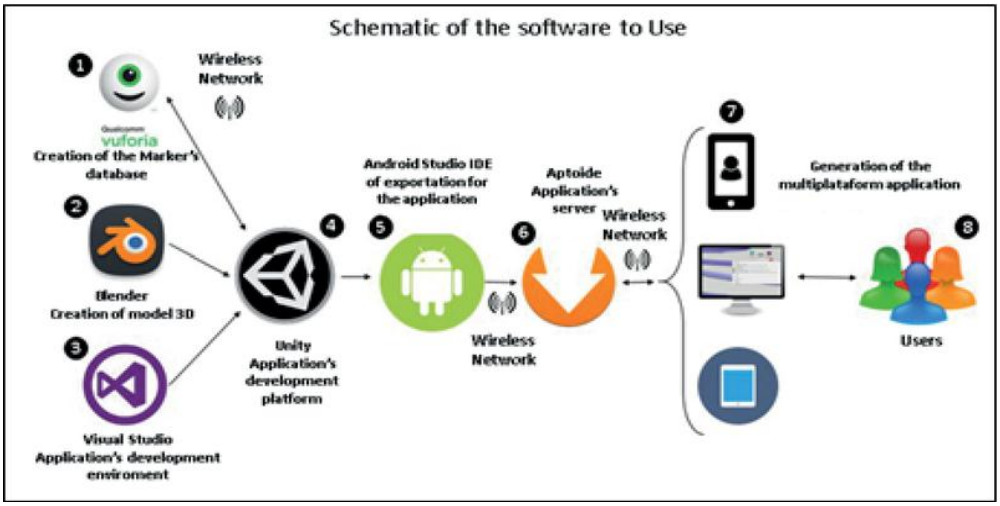

Fig 2. Proposed Methodology for the AR based mobile application

The task is divided into 5 steps as shown below:

- Image Target Generation
- Importing it into Unity 3D
- Placing of 3D Model on the Target Image and Scripting
- Testing
- Building Android APK for the Project

Proposed Algorithm for developing the AR based mobile application

- Step 1: Select your target images or design the same using any 3D modeling software.
- Step 2: Create actual image targets using different tools. However, in this approach we have used Vuforia Target manager to set the target.
- Step 3: Import and select the database that needs to be deployed on the unity 3D .
- Step 4: Placing of the 3D model on the image target and develop equivalent scripts for the same.
- Step 5:.build the application to validate the presence of tumor and color code the same to distinguish between the benign and the malignant tumor in the human brain.
- Step 6: Test the working of the application by supplying the mri image of the brain captured through the camera for validation

Results and Discussion

In the work carried out, although there are a variety of image targets type available, this work focuses on marker-based technique where the anchors are developed by the user to create a virtual feel for the data in the real time environment with the aid of distinct pattern. Thus, the work carried out here uses marker based target generation technique to track and detect the image by comparing the existing image against the database source of the target image. In the point of discussion, we consider the working environment of Vuforia Engine for the complete design of image targets and deploying the same in the real environment. The advantage of using this tool is the image targets can be easily downloaded as a package, which can be further used with unity for integration. However if the size of the dataset that is being used for tracking is huge, then the Vuforia target manager uses the feature of cloud technology to recognize and track thousands of such imaged deployed in the cloud effectively. The advantage of using this tool is it generates the scores for the recognition of the image targets efficiently. BR35H 2020 [11] dataset is used which contains 255 negative and 255 positive MRIs of brain tumor. About 430 samples have been used for the training and the remaining are used for the validation. The usability rating of this dataset is reported as 7.5 [12] based on the factors that were used to evaluate by the public as available in the public kernel.

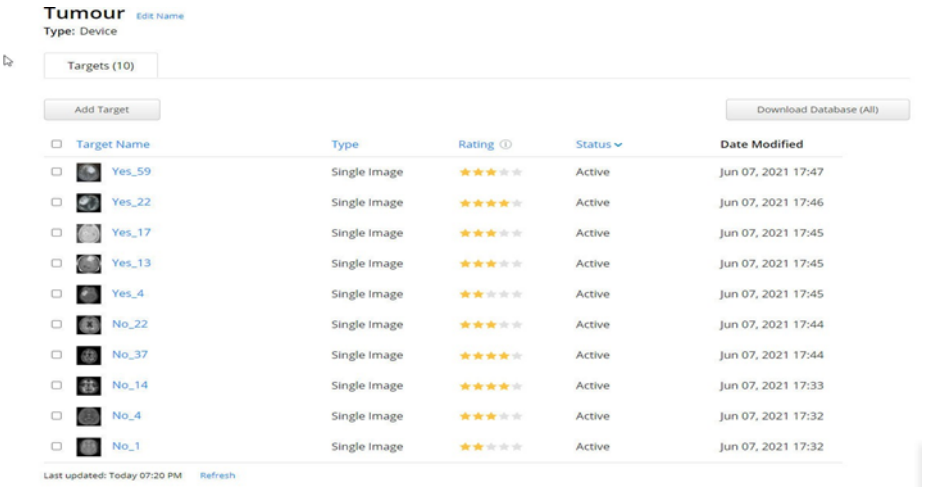

Fig 3. Image Target with their recognition score on Vuforia Development

The image targets once created, detected and tracked now needs to be downloaded from the Vuforia development kit [13] which would then be uploaded as a database and be imported into unity 3D software for further evaluation.

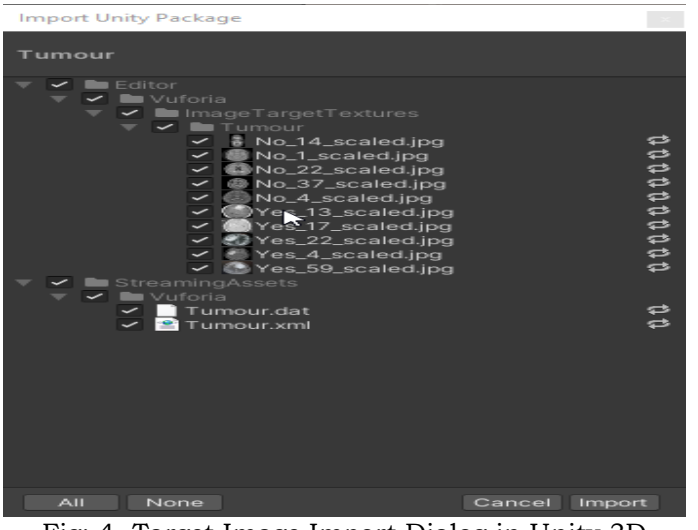

Fig: 4. Target Image Import Dialog in Unity 3D

Now that the database is ready for the tracking of the image, a sample image needs to be identified form the database that is imported by clearly indicating the name of the database.

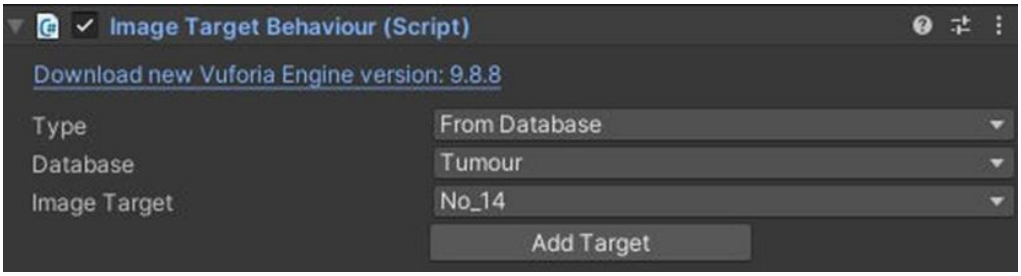

Fig 5. Sample Target Image selection from Database

Next step is to place the model on the image target in AR but by placing the 3D[14] type of the model appropriately with respect to the original data set that is created.

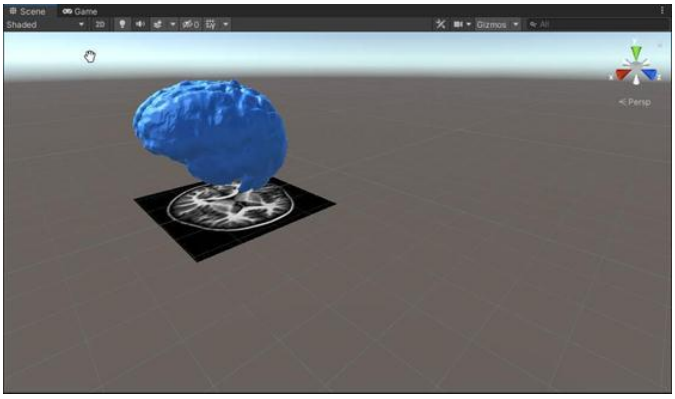

Fig 5. Sample 3D Model and Target Image in AR

From the above image we understand how actually a 3D Model is placed on a target image and similarly we place the 3D Model for various other target images. In the work carried out, Blue Coloured 3D Brain Model represents that the particular target image is a normal brain MRI while Red Coloured 3D Brain Model represents that the particular target image is a brain with tumour.

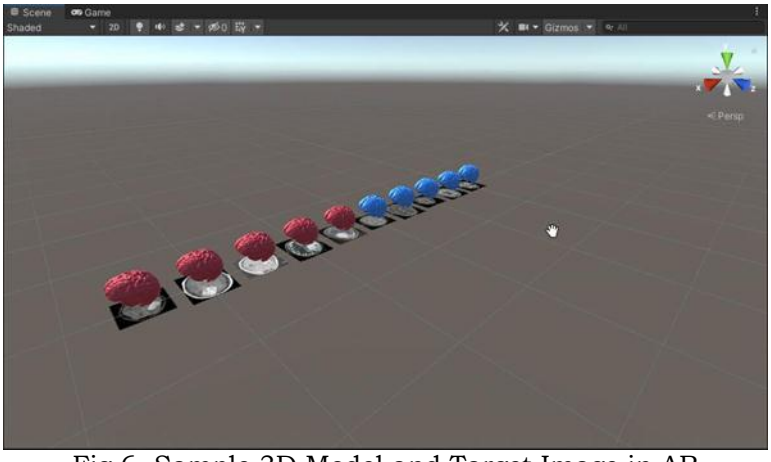

Fig 6. Sample 3D Model and Target Image in AR

Using the player settings, we need to add information related to the apk based on the base version of the android. After saving the “Player Settings” , in the “Build Settings” click on the option ”Build And Run” and the save the APK File on the system and then test the same on any Android Phone.

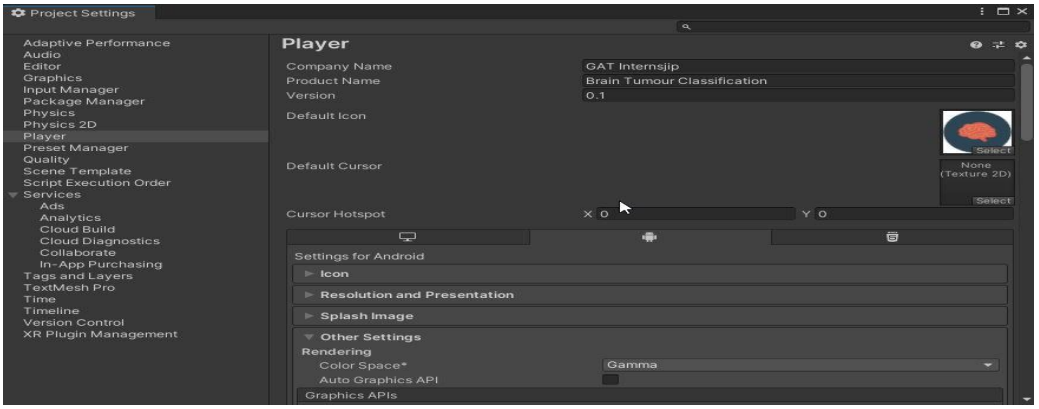

Fig 7. Player Settings in Unity 3D

Testing

In this section we use the play segment to run the AR Project and use our external webcam to test our project. Target Image 8: For the first target image we shall consider a Normal Brain MRI and check whether it displays blue coloured 3D Brain Model in AR.

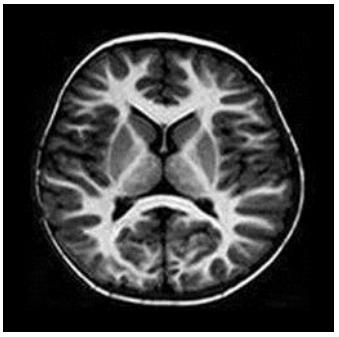

Fig 8. MRI Scan of Normal Brain

Output

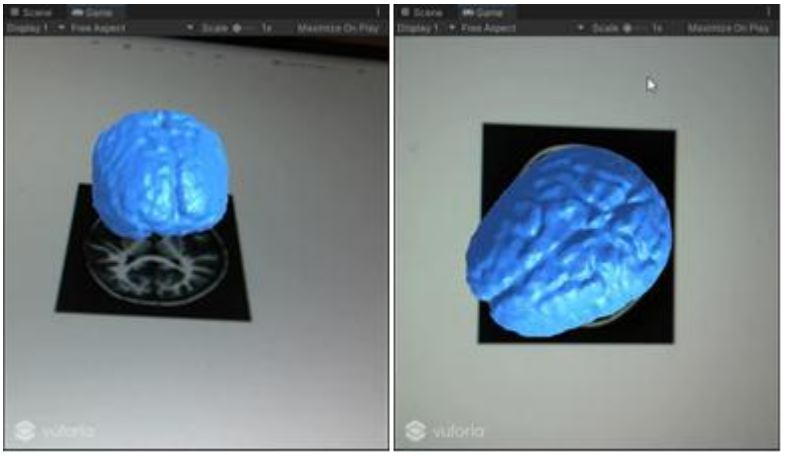

Fig 9. Blue Colour Brain Output in AR

Target Image 9 for the first target image we shall consider a Tumour Brain MRI and check whether it displays Red coloured 3D Brain Model in AR.

Target image

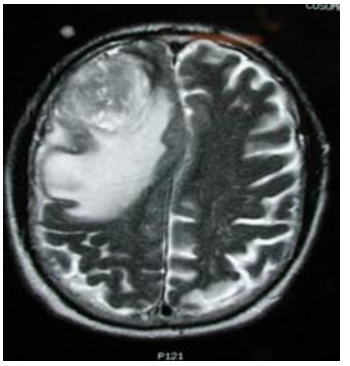

Fig 10. MRI Scan of Normal Brain

Output

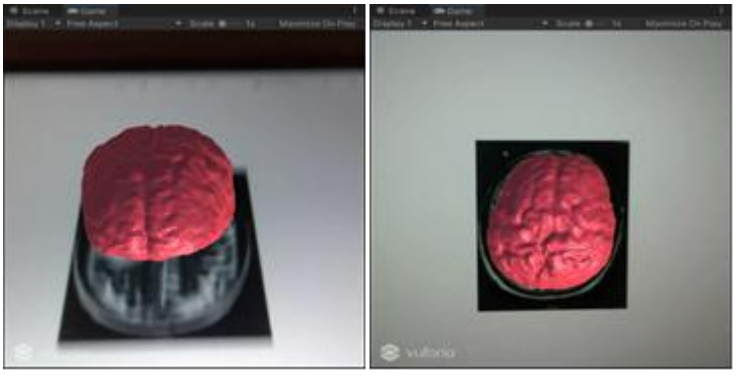

Fig 11. Red Color Brain Output in AR

Conclusions and Future Work

It is very clear from the proposed work that a smart mobile application is indeed very helpful for the physicians to provide concrete information about the diagnosis of presence of tumor. Thus, we can conclude from this work that computer assisted aid is very helpful in supporting the decisions made from the medical data. In addition, we can conclude from the above findings that an automated system incorporates augmented reality to classify the tumor as benign or malignant. Hence, in future the work can be extended by developing suitable application for performing localization of tumor and enhance the work to automate the grading of the level of tumor without compromising with the existing infrastructure and performance of the underlying system.

References

1. Battineni, G.; Sagaro, G.G.; Chinatalapudi, N.; Amenta, F. Applications of Machine Learning Predictive Models in the Chronic Disease Diagnosis. J. Pers. Med. 2020, 10, 21. [CrossRef]
2. 2. Topol, E.J. High-performance medicine: The convergence of human and artificial intelligence. Nat. Med. 2019, 25, 44–56. [CrossRef]
3. Kai Klinker, ManuelWiesche, Helmut Krcmar (2019) “Digital Transformation in Health Care: Augmented Reality for Hands-Free Service Innovation”,Inf sys front 22,1419-1431.
4. Toktam Hatami, Mohammad Hamghalam, Omid Reyhani-Galangashi, Sattar Mirzkuchaki, — A Machine Learning Approach to Brain Tumors Segmentation Using Adaptive Random Forest Algorithm, IEEE 2019.
5. Explainable Artificial Intelligence for Human-Machine Interaction in Brain Tumor Localization, Morteza Esmaeili, Riyas Vettukattil, Hasan Banitalebi, Nina R. Krogh and Jonn Terje Geitung , 2021
6. Multi-Classification of Brain Tumor MRI Images Using Deep Convolutional Neural Network with Fully Optimized Framework, Emrah Imarak,2021
7. Recent Development of Augmented Reality in Surgery: A Review,P. Vávra, P. Zonča, Ihnát, M, Něme,J. Kumar, N. Habib,and A. El-Gendi,2017
8. Angel Cruz-Roa, John Arevalo, Alexander Judkins, AnantMadabhushi, Fabio Gonzalez “A method for Medulloblastoma Tumor Differentiation based on Convolutional Neural Networks and Transfer Learning”, IEEE, 2016.
9. MuhammedTalo, UlasBaranBaloglu, OzalYildirim, U RajendraAcharya “Application Of Deep Transfer Learning For Automated Brain Abnormality Classification Using MR Images”, IEEE, 2017.
10. Computer-Aided Brain Tumor Diagnosis: Performance Evaluation of Deep Learner CNN Using Augmented Brain MRI,Asma Naseer, Tahreem Yasir,Arifah Azhar , Tanzeela Shakeel , and Kashif Zafar , 2021.
11. Pohl M. mHealth App Economics 2017 – current status and future trends in mobile health. November 2017. https://research2guidance.com/325000-mobile-health-apps-availablein-2017/.
12. Kopp M. A future in digital health. Transforming healthcare for patients and providers.
13. SAP Digital Healthcare Paper.https://www.sap.com/industries/healthcare.html#pdfasset=a864cb4c-d67c-0010-82c7eda71af511fa&page=2. Accessed: 2 Nov 2018.

14. Barsom, E. (2014). Augmented reality in medical education? Perspect Med Educ. , 300-311.
15. Billinghurst, M. (2009). Advanced Interaction Techniques for Augmented Reality Applications. International Conference on Virtual and Mixed Reality , 13-22.