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A Survey on Real Time 3-D Object Detection and Tracking Techniques for Marker-Less Augmented Reality

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Abstract: ***Augmented Reality is a super imposed computer generated image on a punter vision of the real world thus providing a composite view. It is a process to pick and choose a factual world view and add your virtual objects in it. Augmented Reality technologies are very attractive to learners since they present new experiences when learning about the real world. The Main goal is to present a practical approach for the development of Augmented Reality in Education that was aimed at the secondary or primary level students. Computer vision based target detection techniques had been successfully applied to marker less augmented reality applications. In this paper, it presents a survey of various methods of real-time object detection that can recognize three-dimensional (3D) target objects, regardless of their complex shapes and lighting condition changes, texture, occlusion and overlapping of multiple objects in the same plane. Information from both RGB and Depth Images are fused for Real time 3D object detection.***

Keywords: Augmented Reality, overlapped, occlusion, RGB and Depth images

1. Introduction

1.1 Augmented Reality

Augmented Reality is a knowledge, which that allows computer created virtual information to cover on top of a live direct or indirect real world Environment in factual time. In cousins of Augmented Reality these are virtual Reality, Mixed Reality. Augmented Reality is different from Virtual Reality in that in Virtual Reality People look ahead to experience a computer generated virtual environment. The result of blending the human world with the digital world it's called as Mixed Reality. Mixed reality is the next progress in human, computer and environment interaction and unlocks possibilities that before now were restricted to our imaginations. Mixed reality systems, which is useful for many real-life application scenarios, like architecture, product visualization [28][52].

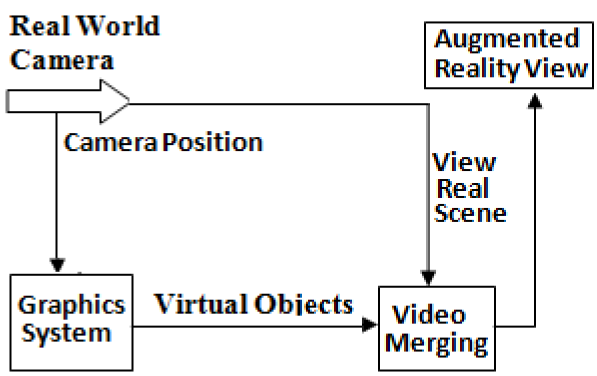

Figure 1.1: Delineate of Augmented Reality systems

Augmented Reality atmosphere is factual but extended with information and imaginary from the system. Augmented Reality bridges the gaps between the factual and the virtual in a seamless way. Virtual Reality and Augmented Reality used an optical see-through head mounted display that was tracker and ultrasonic tracker. Augmented Reality based on the following three properties: a) combines factual and virtual objects in a real environment b) runs interactively, and in real time c) aligns real and virtual objects with each other. The main feature is being register in a 3D space used in augmented reality [1][32].Augmented Reality system can either be marker based augmented reality or marker-less based augmented reality. Marker based applications are designed as a Rectangle image holding black and white area inside it.

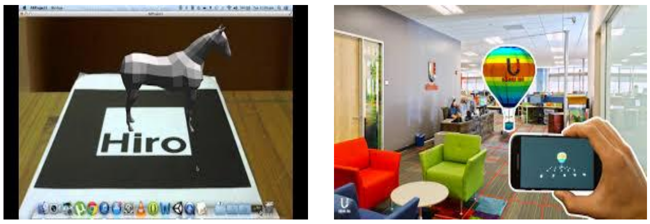

Figure 1.2: Diagram of Marker based and marker less Augmented Reality [45]

Marker-less augmented reality applications have wider applicability because they function anywhere without the need for special tagging points. Augmented Reality towards the ultimate goal of Augmented Reality displays that can operate anywhere in any Environment and make a factual. Graphic Engine did not have sufficient power to draw the menus and command names on real wall and allowed the user to virtually select one of the real signs by pointing at one with the hand controller. Research efforts have focused on the proper alignment of virtual with real. AR system and the alignment among technology design, instructional approach, and learning experiences may be more important[37].An extendable AR or VR system is needed as a platform to develop an application for real use in classrooms.

1.2 Motivation of Augmented Reality

Motivation was to allow the user to issue command.AR systems that provide accurate registration outdoors are of interest because they would make possible new application areas and could provide a natural interface for wearable computers an area of growing interest both in academia's an industry. Tourists that visit historical sites. Tourist and students walking around the grounds with such AR displays would gain a much better understanding of these historical sites and the important events that took place there. The ultimate goal is to create a system such that the user cannot notify the difference between the real world and the virtual augmentation of it [1][10].The insists on product and development process of today's business are rising in terms of flexibility of scale in Combination with product variant flexibility [1].The Marker less AR system which is based on detecting interest points in the form of features and then assigning descriptors. These extracted characteristics are then used to augment the virtual graphics with the real world. Marker less AR system has not only proven to be better than maker based systems but also have clearly outnumbered the number of divergent applications which can be realized in the field of Augmented Reality.

1.3 Tracking System in Augmented Reality

Marker less system involves tracking and registration techniques which might be a little more complex to handle [2][10].An optical tracking system is utilized to unobtrusively record the routes of each assembly operator with in a particular work place. These trajectories are subsequently processed and segmented via neural network approach.[3][10]. An object detection that can handle 3D target objects, regardless of their texture and lighting condition changes. Local feature descriptors have also been introduced to depth based object recognition and RGB-D cameras which capture colour and depth images become widespread recently the RGB and Depth information have been considered together for object recognition and pose estimation [5].Maker less AR under everyday conditions and identify classes of applications suitable for the achievable accuracy [6].MAR approach based on real time 3D reconstruction using a low cost depth camera the Kinect. A reference 3D model is built with a real time 3D reconstruction algorithm and next the user positions the virtual object into the reconstructed model [7]. In MAR any part of the real environment may be used as a marker that can be tracked in order to position virtual objects. Tracking and registration techniques become more complex in MAR systems. Another disadvantage emerge in online MAR since it presents more restrictions [4].This section presents a practical approach to the development of educational AR content [8].The tracking techniques that allow alignment in real time of real and virtual worlds using images acquired by moving camera. A MAR 3D model based algorithm is first used for the tracking of objects in monocular image sequences. The Main Advantage of a model based methods that the knowledge about the scene [9]. The Augmented Reality Comprises of two stage processes. In first stage, a set of features is learned with the help of an external tracking system while action. The second stage uses these learned features for camera tracking when the system in the first stage[11] .One of the most critical issues for AR application designers is ensuring that virtual objects appear in the correct places in the real world and are perceived accurately relative to other virtual and physical objects scene[12].Picture books as the experimental material to realize marker less AR, because the picture books contain many artificial images that are more easily to apply for object recognition. The marker less mechanism is to identify the image contours using the point matching algorithm: Scale-invariant framing.[13].ICP algorithm is a widely used approach for 3D shape registration.ICP was not originally designed for medical imaging, its proven effectiveness has made it the most popular surface matching algorithm for medical imaging applications[14].A video based AR system with marker tracking which mixed virtual images on the real world. They used fast and accurate computer vision techniques to track the fiducially markers through the video [15].The Segmentation of individual objects is realized using the depth, occlusion, colour, and motion cues [16]. A Local Descriptors technique is mainly used for finding correspondences between two images [19]. The descriptor vectors are matched between different images. The matching is based on a distance between the vectors [20]. Template-based visual tracking algorithms and model-free vision-based control techniques [21]. Depth cameras are not conceptually new Kinect has made such sensors accessible to all [25]. Real-time 3D object detection and Simultaneous Localization and Mapping (SLAM) that require scale and perspective invariance, involve a very large number of classes, but can tolerate significant error rates since we use robust statistical methods to exploit the information provided by the correspondences [24]. This boosting algorithm does not require any prior knowledge about the performance of the weak learning algorithm [26]. The ICP (Iterative Closest Point) algorithm is widely used for geometric alignment of three-dimensional models.[27]. 3D-to-3D registration was created between the model (Stereoscopic) and the surgical recording using a modified iterative closest point technique [31][49].

1.4 Applications of Augmented Reality

1.4.1 Education

Augmented Reality technology with the educational substance creates novel type of automated applications and acts to improve the effectiveness and attractiveness of learning and teaching for students in real life scenarios [31]. In chemistry education Augmented Reality the most suitable solution for the current problems and faced with in instruction on chemistry micro-worlds, as micro-particles are cannot be observed in reality. Augmented Reality technology to middle-aged enough that students in 2030 ,it be routinely building Augmented Reality educational content, thereby tightly connecting the classroom knowledge to the world around them[50].

1.4.2 Mobile AR Applications

AR experience anywhere, which means that students can remain actively hold in the learning process exterior as well as interior the classroom. The mobile GPS and range sensors set the user's location and point of view ,so that the application can position the virtual reconstructed building within the remains of the real building.

1.4.3 Military Augmented Reality

In military applications use Heads-Up Display (HUD)and it is typical example of augmented reality. A transparent display is positioned directly in the fighter pilot's view. Data typically displayed to the pilot includes altitude, airspeed and the horizon line in addition to other critical data.

In a ground troops Head-Mounted Display (HMD) is used. Critical data such as enemy location can be presented to the soldier within their line of sight. This technology is also used for simulations for training purposes [52].

1.4.4 Medical Augmented Reality

Augmented Reality knowledge to practice surgery for medical students in a controlled natural environment. Visualizations helps in explaining complicated medical conditions to patients. Augmented reality can decrease the risk of an operation by giving the surgeon improved sensory observation. In this technology can be combined with MRI or X-ray systems and fetch everything into a particular view for the surgeon. Neurosurgery is at the forefront when it comes to surgical applications of augmented reality. The ability to image the brain in 3D on top of the patient's actual anatomy is powerful for the surgeon. Since the brain is somewhat fixed compared to other parts of the body, the registration of exact coordinates can be achieved. Concern still exists surrounding the movement of tissue during surgery. This can affect the exact positioning required for augmented reality to work [52].

2. Methodology

Marker less Augmented Reality is when objects are tracked based on location can be anything else book picture, human body, head, eyes, hand or fingers etc on top of that you add virtual objects. Marker less Augmented Reality techniques classified into two categories these are Model based Augmented Reality and Structure from Motion based markerless augmented reality. In model based techniques, knowledge about the factual world is stored in a 3D model that is used for estimating camera pose. In Structure From Motion based techniques, camera movement throughout the frames is estimated without any previous knowledge about the scene, which is acquired during tracking. Model based methods are often simpler than SFM Based ones, but tracking depends on the visibility of the previously modelled objects in the real world image.

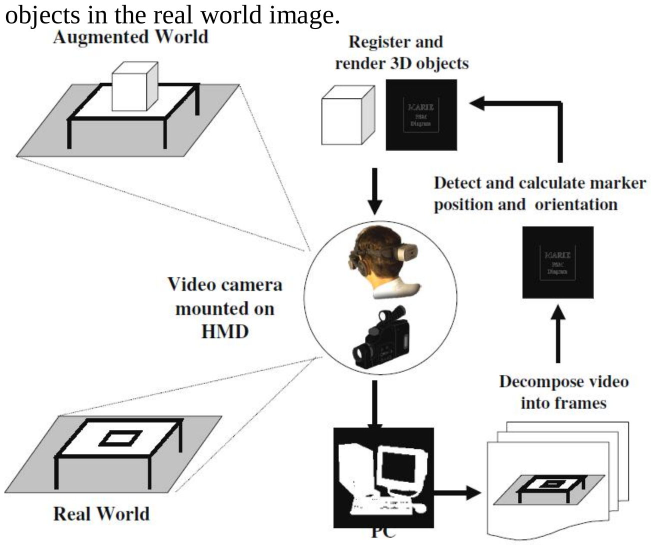

Figure 1.3: Architecture of Augmented Reality systems [45]

Table 2.1: Model Based Techniques

S.No	Method	Datasets	Object Selection Methods	Advantage	Disadvantage
1	Edge Based	Video Data	Object pose select Manually	1.Low Complexity 2.Easy to Implement 3.Good Performance	1.Only used specular object 2.Environment lighting condition 3.donot support fast camera motion
2	Optical Flow Based	Video Data	Selected by a Temporal Information	1.Moderate processing load need errors produced by sequential pose estimation	1.Not robust against lighting changes and large camera displacements originating errors in object tracking requiring re-initialization
3	Texture Based	Image and Depth Data	Template matching method	1.Illumination changes are easily achievable	1.No prior knowledge about any points in the scene

Table 2.2: SFM Based Techniques

S. No	Method	Datasets	Object Selection Methods	Advantage	Disadvantage
1	Real-Time SFM	Video Data	"Feature tracking, basic matrix extraction and modification, camera pose estimation and self calibration"	1.More Information about entire scene	Solving only Linear Equation
2	Mono SLAM	Video Data	SLAM using a single liberally moving wide-angle camera as the only sensor and with a real time constraint.	1. Good Features selected Sequential Bayesian inference and "normally uses sensors such as laser range-finders and sonar". 2.low level jitter and "drift-free while being robust to handle extreme rotation occlusion and closed loop"	It runs at 30 frames per second

Table 2.3: Survey Analysis of Augmented Reality Techniques

Method		Input	Dataset	Pre-Processing	Segmentation	Feature Extraction	Classification	Strength	Weakness
Tracking	[2]	Depth image and RGB image	Natural Video	Gaussian function	GrapCut	SIFT, HOG	SVM	It works efficiently	Execution time is high

Optical Tracking	[4]	3Dimentional skeletal data	Pre trained dataset real shop floor	Nil	Walk path	Two layered Feed forward Neural network	Multilayer Neural Network	Neural Network better finding error	Optimize segment more distinct work task
Still Object Detection	[7]	Depth image and RGB image	Natural Video	Different lighting condition, Gradient Computation	Nil	Template Matching, Texture and geometry Information, pose Estimation	Nil	Detected object by complex shapes and insufficient texture and different lighting condition	Stable pose
Moving object	[8]	Natural Video	Berkeley Multimodal human action	Nil	Nil	Spatio temporal interest point	Dempster Shafer theory classification,	Tracking is based human action	Two types of cameras to be used for capturing image
Tracking	[9]	Live stream	Natural Video	Nil	Viola-Jones face detector	3D model	Nil	Support occluded	To improve accuracy
Track Optical flow	[10]	Live stream	Natural Video	Nil	Nil	ORB Binary features	Nil	Pose Unique Challenges	To improve speed
Tracking	[11]	Live stream	Natural Video	Nil	Nil	Corner features edge	Nil	Slower process to estimate the pose	Lower resolution images
Tracking	[13]	Live stream	Natural Video	Nil	Nil	SIFT	Nil	Alternative reading	Accessible only rectangle block
Tracking	[14]	Live stream	Natural Video	Nil	Nil	Corner detection edge, ICP	Nil	More accurate	Not work with real person
Tracking	[15]	Live stream	Natural Video	Nil	Nil	ICP	Nil	Pose estimation to detect a object accurately	To improve accuracy

Table 2.3 reveals Marker less Augmented Reality techniques namely Object Detection and Moving Object Detection, Object Tracking.

Table 2.4 Comparison table for Marker less Augmented Reality and Marker based Augmented Reality

Comparison	Aspects	Marker-Based Augmented Reality	Marker-Less Augmented Reality
Methods	Relative Position/Angle	Depends on markers	Depends on Localization Technology and gyroscope
	Augmented Reality Software Development kit(SDK)	Commonly used	Rarely used
Position Accuracy	High/Low Influence Factors	Relatively higher Brightness	Relatively higher Localization technology
Stability	High/Low Influence Factors	Relatively Lower Markers &SDKs	Relatively Higher Localization technology and gyroscopes
Hardware Support	Desktop Mobile	Supported Supported	Usually not Supported Supported

3. Performance Metrics

A Performance metric measures an algorithms behaviour, activities and performance. In this section, contains a video sequences under a varying lighting condition and detection performances of an object. To found out the false detection based on Alpha values. Alpha value is scaling factor, alpha value is zero detection object is occurs at many false detection and alpha value is 0 to 1 best result is achieved [7].

3.1 False Detection Rate

This is the percentage of class 2 patches classified as class 1 patches. It is defined as:

$$\text{False Detection Rate} = \frac{FP}{TN + TP} \qquad (1)$$

Where FP is the number of false positives and TN is the number of true negatives

Jitters occur in the estimate pose when targets surface is occluded by other objects. Jitter is the deviation from true periodicity of a presumably periodic signal often in relation to a reference clock signal.

Table 3.2: Results of Pre-processing techniques

S.No	Pre-processing techniques	MSE	PSNR
1	Gaussian filter	0.25	43.2
2	Gradient Computation	0.43	45.2
3	**Median filter**	**0.52**	**50.3**

Table 3.3: Segmentation techniques

Method	TN	FP	Accuracy
GrapCut	0.86	0.24	87%
Walk path	0.54	0.46	60%
Viola-Jones face detector	**0.77**	**0.23**	**78%**
Otsu Throsholding	0.66	0.34	70%

Table 3.4: Feature Extraction Techniques

Method	Kpts1	Kpts2	Matching points (%)
SIFT	256	230	87%
HOG	142	64	57%
ORB Binary features	323	296	88%
ICP	324	234	80%
Harris Corner	**324**	**294**	**89%**

Table 3.5: Classification techniques

Method	TP	FP	TN	FN
SVM	56	25	10	9
Multilayer Neural Network	64	7	16	13
Dempster Shafer theory classification	75	11	4	10

Table 3.6: Template based matching techniques

Procedure	CPU	GPU
Gradient Computation	10.7	0.5
Template Matching	39	10.2
Total	49.7	10.7

4. Conclusion

This paper discussed about the different techniques of Marker less Augmented Reality technologies. Various types of Model Based Marker less Augmented Reality and Structure from Motion (SFM) models technique and the results are compared. Marker Less Augmented Reality techniques are compared, and concluded that in Pre-processing stage Gaussian filter is better of visual quality and a segmentation stage GrapCut algorithm accurately segmented the object from a live stream. In Feature Extraction Iterative Closest Point algorithm is found to be the best to identify object easily. When Iterative Closest Point is fails, Pose estimation algorithm is gets better solutions compare than Iterative Closest Point for motion object detection in Marker less augmented reality and it runs in real time.

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