Real-Time Pre-placed Marker-less Square-ROI verification system based on Contour-Corner approach for breast augmentation

Rechard Lee, Abdullah Bade, Salina Sulaiman, and SitiHasnahTanalol
School of Sciences and Technology, University Malaysia Sabah, Kota Kinabalu, Malaysia
Email: rl_mr@yahoo.com, {abade, salina, hasnah}@ums.edu.my

***Abstract*—This paper aims to enhance the current contour and corner detection approach by applying smoothing and adaptive thresholding techniques to the stream input and then use subpixel corner detection to obtain better and more accurate interest point. There are two main steps involved in AR application, first - detect and extract local features and second – visualization and rendering. Our focus is the first part of the whole operation – features. We proposed marker-less approach as to avoid the needs to prepare the target environment and to make our approach more flexible. The proposed method starts with first getting an input from the real environment thru a camera as visual sensor. On receiving an input image, the proposed system will process the image, finds and detects strong interest point from the ROI by applying enhanced contour-corner detection. From the ROI, features such as number of corners and vertices can be extracted and later can be used to determine a marker. For testing purposes, a mannequin as an input is used. Based on the experiment, the proposed method manage to capture the environment, convert captured frame into grey-scale image, detect corners and contours and also able to identify and verify a marker.**

***Index Terms*—augmentedreality, contour detection, corner detection, marker-less**

I. Introduction

An effort to enable the use of Augmented Reality (AR) in combination with computer vision techniques in the medical field has been started since the early 1990s. AR can be described as a technology which is developed by using computer vision techniques and image processing methods in order to enhanced user vision and perception. Ref. [1] defined AR as a research field in which user's vision is enhanced by combining real world scene and computer generated objects into the identical real environment space called mixed reality (see Fig. 1) Whereas, Azuma [2] defines an AR as a systems that have the following characteristics:

- Combines real object with virtual object,
- Interactive in real-time, and
- Registered in three dimensions.

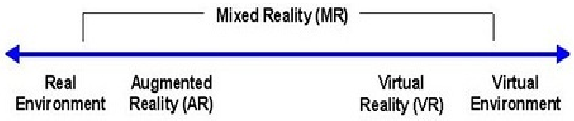

Figure 1. Milgram's Reality-virtuality continuum [1].

Later, in 2002, Mann [3] come up with a two-dimensional reality-virtuality-mediality continuum as an effort to add another axis to Milgram'svirtuality-reality continuum by adding mediated reality and mediated virtuality (see Fig. 2). In [3], system can change reality in three ways:-

- Add something (augmented reality)
- Remove something (diminished reality) or
- Alter the reality in some other way (modulated reality)

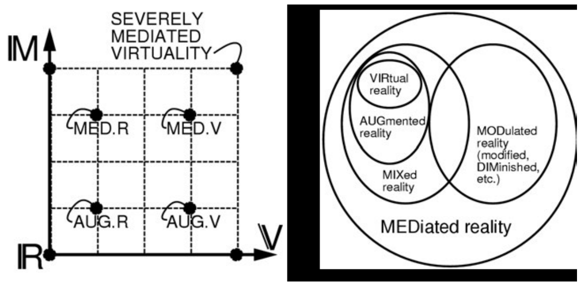

Figure 2. Mann's Reality-virtuality-mediality continuum [3].

Various studies have been conducted to explore the fundamental concept and unique potential of Augmented Reality technology to be applied in mainstream application such as in medicine, training, simulation, industry, broadcasting and education – and yet most of it is marker-based application due to its ease of development and higher rate of accuracy and success despite its lack of flexibility in unprepared environment. In the field of medicine, the use of computer generated images such as CT-scan or MRI as a vision aid to the surgeon in surgical planning has increased dramatically over the years. With the use of an AR system, we believe that the surgeon's vision will be enhanced, more data can be obtained, ensure proper surgical planning thus avoiding unnecessary cutting in real surgical operation.

Computer vision (CV) on the other hand is a field which is strongly related in (AR) application

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development and success.According to Marr and Nishihara (1978) [4], “vision is a process that produces, from images of the external world, a description that useful to the viewer and not cluttered with irrelevant information”. In AR application, CV works hand in hand with scene understanding and analysis. Sub-areas of CV can be seen in motion detection, face detection, object tracking and recognition etc. The process to correctly combining the real scene with virtual objects and accurately register the mixed scene depends greatly on CV potentials to extract and detect features either naturally from the desired region of interest (ROI) or based on fiducial marker that present to the camera. Ref. [5], considered the use of CV techniques as a starting point in detecting a fiducial marker or natural marker in order to solve the registration and tracking issue in AR application.

Used of printed square marker (see Fig. 3) or customized pattern which is located physically on top of the target area or workspace in medical field is not practical and not user-friendly.

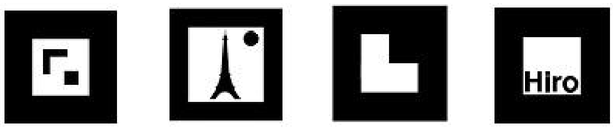


Figure 3. Example of Printed Square Markers.

Therefore, in this paper, we proposed and describe a real-time marker-less identification system designed to capture real scene, detect strong interest points from extracted contour, verify a marker and overlay 2D object. Extracting and detection of features from the real scene will be our concerns in recognizing a marker.

Our proposed method use the combination of contour and corner approaches in order to find unique natural features from captured frame through a web cam in real time. Generally, feature points [6], edges [7], curves [8], planes and so on, are used for registration. Even though, extraction of such natural feature is more difficult than the artificial vision marker based approach, the user’s movement range is not limited, ensure real scene augmentation and no preparation needed to setup the marker. Therefore it is preferable to use this approach over printed marker. The remainder of this paper, will be discussing about the basic setup of AR system, marker and marker-less detection, contour-corner approach and an initial result for the presented methods will also be given and illustrate.

II. Materials and Methods

A. Simple AR system setup

Basic setup of an AR system consists of mobile computing unit such as PDA or mobile phone and head-mounted display (HMD) to which a miniaturized camera is attached. There are two types of HMD generally used; namely optical see-through (see Fig. 4) and video see-through (see Fig. 5).

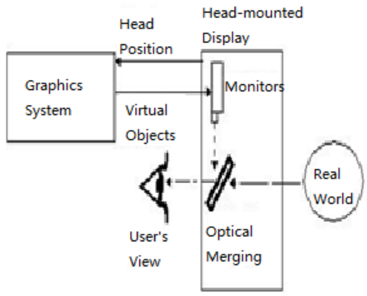


Figure 4. Optical See-through Augmented Reality Display [9].

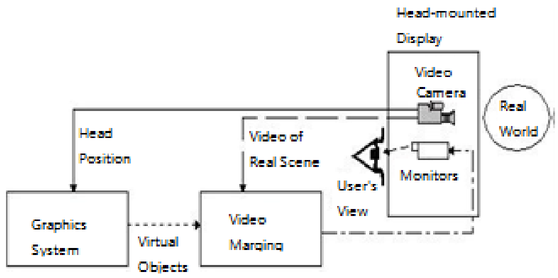


Figure 5. Video See-through Augmented Reality Display [9].

The miniaturized camera therefore captures the real environment from the user’s perspective. The AR system processes these live images in real time extracting features to identify markers. Markers are identified using point and edge detectors. The features can be artificial printed markers, natural marker or natural features.

B. Vision-based AR

Researchers in computer vision have proposed and developed several methods in tracking and detection that can be applied in AR registration. This method can be sub-divided into three types based on the equipment used; sensor-based, visual-based and hybrid-based. Since camera is already part of the AR system, visual-based methods are used together with vision-based registration technique.

Approaches for visual-based tracking are marker-based and markerless-based methods. Used of marker-based method have been discussed in [10], [11], [12] and [13]. Whereas, [14], [15] and [16] have established a markerless-based method for unprepared environment. Most researchers opted for marker approach, since it is more accurate and reduce computation-resources [17]. However, for outdoor or unprepared environment, marker-less approach is more suitable despite suffered from computation time-consuming [18] and [19].

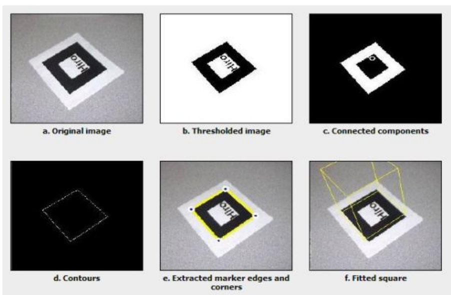


Figure 6. Marker-based ARToolkit Algorithm [20]

C. Approach to Marker-less Square-ROI verification

As demonstrated in Fig. 6, marker-based detection algorithm needs to go through stage (d) and (e) respectively in order to implant an object for the detected marker. These two steps are the main inspiration for our proposed method.

By combining Contour-Corner approach we believe that we can somehow replace the needs to have a physical marker in the desired environment. Instead of using a physical marker, we will define a Region of Interest (ROI) as a marker-less marker, called Square-ROI. This pre-placed Square-ROI need to be hand-drawn manually by the user (see Fig. 9 (a)). The reason we chose a Square is because squares naturally produces 4 possible points and these 4 points are needed to calculate the pose camera estimation for visualization rendering purposes. Other reason is that, the orientation of the points can be estimated as intersections of edge lines.

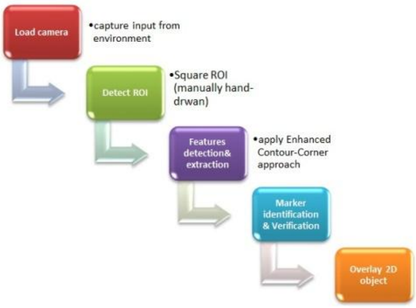
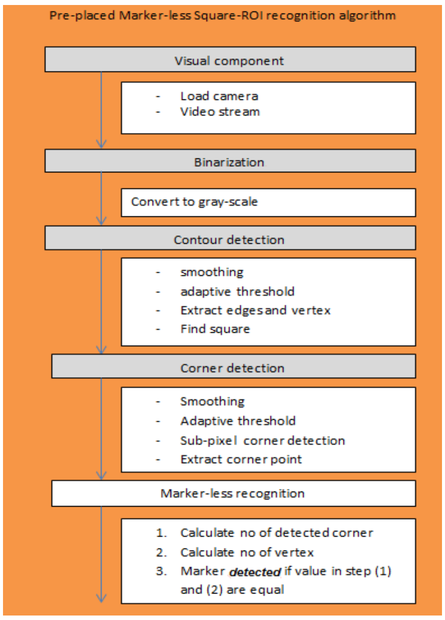
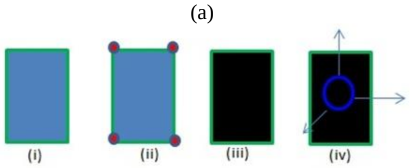


Figure 7. Pipeline for Proposed system.



(a)



(b)

Figure 8. Overview of proposed method (a) Algorithm (b) Marker identification Illustration (i) draw detected contour (ii) draw detected corner (iii) Identify marker (iv) overlay an object.

As discussed by [21], a marker-less recognition system need to fulfill some criteria as stated below:

- Easy offline preparation
- Automatic initialization
- Able to detect natural features reliably
- Reasonable computation time
- Accurate augmentation
- Work in unconstraint environment
- Flexible and adaptive to the application needs

D. Workflow and Algorithm

As illustrated in Fig. 7, we can see that the process starts with first getting an input from the real environment thru a camera as visual sensor. On receiving an input image, the proposed system convert the video stream, performs threshold and smoothing , finds and detects strong interest point from the ROI by applying enhanced contour-corner detection. Features such as number of corners and vertices can be extracted more accurately by applying subpixel corner detection and edge detection. Later, the extracted featurecan be used to identify and verify a marker.

III. Initial Results and Conclusion

A. Initial Results

We present the results of our proposed method based on the test conducted on a mannequin as an input (real environment) in our experiment.

A square is manually drawn on top of the target area as a region of interest (ROI) in order to place a non-printed marker or we can say a marker-less ROI (see Fig. 9 (a)). The rationale to manually hand drawn a square contour as ROI is to avoid the needs to prepare a printed marker and at the same time to make our proposed system more flexible with unprepared environment. Thus, we can ensure that only desired area of the image is searched for features.

We formulate that number of vertices detected on a contour (square) must be equal with the number of corners detected in order to identify a marker and upon successfully identified, a yellow circle will be overlay on top of the target area (see Fig. 9 (d)). Yellow circle used as a substitute for 3D breast object in this test.

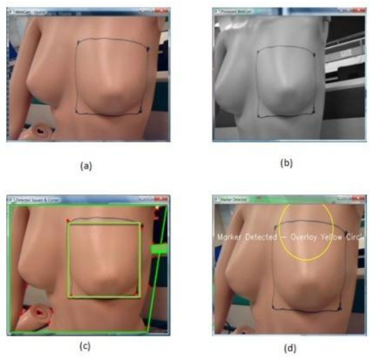


Figure 9. Initial results of proposed system: (a) Load camera and capture theenvironment(b) Convert captured frame into grey-scale (c) Display detected corners and square (d) If marker detected(Overlay 2D Yellow Circle)

B. Conclusion

Based on our experiment in section III, the proposed system manages to do the followings:

- Capture frame through a camera.
- Convert captured frame into a grey-scale image.
- Detect four (4) vertices and four (4) corners.
- Identify and verify a marker
- Overlay 2D object.

At the moment, our proposed methods have the tendency to detect unwanted contour and corners as shown in Fig. 9 (c).

In the future, we would like to extend our algorithm/method to properly visualize the coexistence of a real and synthetic 3D breast cancer model that sharing the same real environment with the aid of visual finger and hand trackingto select and draw the Region of Interest(ROI) in real-time.

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Dr. Abdullah Bade holds MSc degree by research in Computer Science from UniversitiTeknologi Malaysia in 2003. He obtained his Doctorate degree in Industrial Computing (Computer Graphics and Visualization) from UniversitiKebangsaan Malaysia in 2008. He has been actively involved in research and manages to secure several research grants from Ministry of Higher Education and Ministry of Science and Technology Malaysia. His research interest lies particularly in developing optimized algorithm for collision detection between objects, Deformable Body Simulation, Serious Games Simulation,Cloth Simulation and Crowd Simulation. Currently, he is part of the School of Science and Technology, UMS and appointed as a Senior Lecturer and Head of Programmes for Mathematics with Computer Graphics. He spends most of his leisure time on listening soft music, surfing internet, reading and travel. Current Research Group is GRAVSLAB (www.gravslab.com)

RechardLeeholds a first degree in Computer Science from University Putra Malaysia completed in 2000. He is currently pursuing his MSc degree by research in Mathematics with Computer Graphics at University Malaysia Sabah. Current Research Group is GRAVSLAB (www.gravslab.com)

Salina Sulaimanholds MSc degree and currently pursuing his Doctorate degree in Mathematics with Computer Graphics at Universiti Malaysia Sabah (UMS). She is currently a lecturer with School of Science and Technology at UMS.

SitiHasnahTanalolholds MSc degree and currently pursuing his Doctorate degree in Mathematics with Computer Graphics at Universiti Malaysia Sabah (UMS). She is currently a lecturer with School of Engineering and Information Technology at UMS.