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The Fixed-Implicit Object Alignment Method for Image Processing

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Abstract

The challenge facing image processing (IP) systems in scenes is the process of seamlessly integrating virtual objects with real scenes. There are several challenges, including the alignment problem, which is the inability to overcome the alignment problem due to the misalignment between virtual objects and their desired locations in real scenes, which leads to a complete deterioration of the system's performance, thus disrupting the image processing process to create an environment and weakening the user experience. Note that the alignment problem appears in the specified region or object, so we use an approach for alignment of fixed objects implicitly. Our experiment focuses on resolving discrepancies between the specified location of the virtual object and the corresponding real object, unlike dynamic alignment that continuously adapts to the entire scene. This work is to fix the virtual object in a fixed reference region within the real-world framework, which led to enhanced results and reduced cases of alignment failure in critical areas.

Key Words: Alignment Problem, Image Processing, Real Object, Virtual Object.

1. INTRODUCTION

The Image Processing Protocol (IP) is a computer technology that creates natural visual perception by detecting shapes, recognizing their locations, and integrating computer-generated elements with the real environment. To assist the public, it has been used in various fields, including computer-aided education, surgery, creativity, the military, and entertainment. [1, 2, 3]. A new generation of human computer interfaces is being developed using IP. Instead of showcasing data for separated presentations, it places the data in its proper context—the real world. In such way, IP obscures the distinction between the user interface and the real environment and combines them in a naturalistic manner, making it possible to create user interfaces, which are easy to use and intuitive, even for complex applications [4]. It is helpful to compare the two technologies because AR and Virtual Reality (VR) are closely related fields. Both involve creating virtual objects that are subsequently incorporated in user's perspective. IP frameworks, on the other hand, present the user with a composite scene that combines real-world objects with virtual ones, whilst VR frameworks strive for complete immersion, replacing the user's environment entirely with the computer generated content. Thus, the user sees their environment from a different perspective [5,6]. The alignment procedure, which is regarded as a delicate problem and has a major impact on the overall operation regarding the IP system [2,3,7], overlays the synthetic and real worlds. Based on identifying key common features as well as geometric transformation principles, the presented thesis proposes solutions to alignment problem in IP. Those solutions have the ability of accurately detecting the correct object position in the real world and also track its motion.

2. THE RELATED WORKS

IP has produced a large number of alignment techniques. Any suggested alignment technique is firmly reliant on the IP application that was used, including IP, mobile, remote controller, etc. A review of certain earlier studies on alignment problem solutions is included in the presented section. The study by Wang and Zhang refers to the use of molecular alignment of strong laser pulses to understand the contrast between matter and light when isometric symmetry is broken, the detection of chiral molecules with high sensitivity, and the use of high harmonics for electron imaging. [8].

An alignment approach for an AR application that relies on a developed display device was provided by D. Cheng and D. Weng. To meet the needs of display device, a motion tracking tool has been suggested in such framework. The moving part regarding real scene was altered with the use of such approach, and the static part has been segmented with the use of several algorithms [9].

In this field, Emilia Pardo is able to use Prolign depth learning to extend the range of (GPS) paths to monitor alignment patterns for use in multiple medical fields. [10].

The researcher Dogan et al used non-scalar multi-chain adversarial algorithms to handle video and text using (LSTM) alignments, which suppresses their cross-stack attacks and has proven to be superior and accurate. [11].

O. Enqvist and L. Svärm suggested a alignment approach that relied on quickly rejecting outliers and identifying inlier matches. A method to address the high percentage of incorrect matches and their impact on alignment error was suggested by this framework. This approach was utilized to whole body CT as well as brain MR data sets [12].

The researchers proposed Li and O'Donoghue a set of common algorithms for accurate dynamic simulation of alignments through previously proposed statistical and theoretical criteria and comparison between them and transformations of statistical properties and probabilities of outputs in highly accurate settings. [13].

Skitsas et al has done an extensive study on the algorithms of the lawyer for wind charts and there is this study that the (S-IG) algorithm is the best, and in case there is scalability in the (Recall) technique it is a practical alternative as it invests in planning profitability and performance. [14].

To process large amounts of data at high speed, machine learning algorithms are proposed from Reddy and Fields to predict accurate optimal relationships by dividing large tasks of building heuristic trees into parts to handle concurrency to reduce the time to align multiple sequences. [15].

For AR systems, D. Schmalstieg and F. Zheng introduced a alignment technique that automatically identified and fixed alignment issues. It may identify the errors and make iterative corrections through employing a pose tracking technique. In order to correct the pose tracking error, feed-back operation has been applied in two approaches, and the key regions were chosen. Proper pose estimate was crucial to such alignment approach's accuracy [16].

3. KANADE-LUCAS-TOMASI FEATURE TRACKER (KLT) ALGORITHM

KLT algorithm, first presented by Kanade and Lucas [17] and then expanded by Kanade and Lucas [18], is one of the most widely used techniques for the tracking of feature points. A sparse feature point set with enough texture to be reliably tracked are automatically detected by KLT method. Then, through estimating the translation regarding each detected point, the summation of the square differences (SSD) between windows that are centered at current position of the feature point and the translated position is minimized. Even though KLT algorithm is over two decades old, it is still extensively used since it is completely automatic and performs competitively when compared to other approaches with regard to runtime as well as feature point quality. The basic workflow of the KLT Algorithm is [19].

1. Detect the first frame's points of interest.
2. Calculates the motion vector between consecutive frames for every point of interest.
3. To obtain a track for every point of interest, vectors of link motion in successive frames.
4. Apply a detector at every frame to add new points of interest.
5. Use steps 1–3 to keep track of both old and new interest points.

4 SUGGESTED APPROACH

Accurately determining the object's position within the frame, determining the object's right rotation, adjusting the size of two objects, and monitoring changes in real object's rotation and position throughout entire video frames are all necessary for this alignment approach. Several tools are used in the suggested alignment approach to meet these requirements, including:

1. Makes use of a reference image as a way for determining the precise position regarding the real object inside each video frame under various sizing and rotation conditions.
2. Use a high-power filter to remove impurities and make the image clearer.
3. Detect real objects within the frame.
4. Track changes in object position using K-Series technology.
5. Predicts the variations in real object rotation during every video frame using accumulating transformation parameters.

The stage of the detection that identifies the real object and determines its rotation and position, is the first stages in this technique. The real and virtual objects in the video frame are aligned at a precise position in the second stage, to filtering the video frames from noise and making the image or frame clearer to accurately determine the locations of objects, then we go to the third stage, which is the stage of detecting the real object within the frame, and the fourth stage is tracking the changes in the position of the object according to its movements using the (KLT) technology, then the final stage, which is the stage of predicting changes in the rotation of the real object during each frame of the video frames using the accumulated transformation parameters.. The diagram or Real-Virtual Object Alignment technique is shown in Fig 1.

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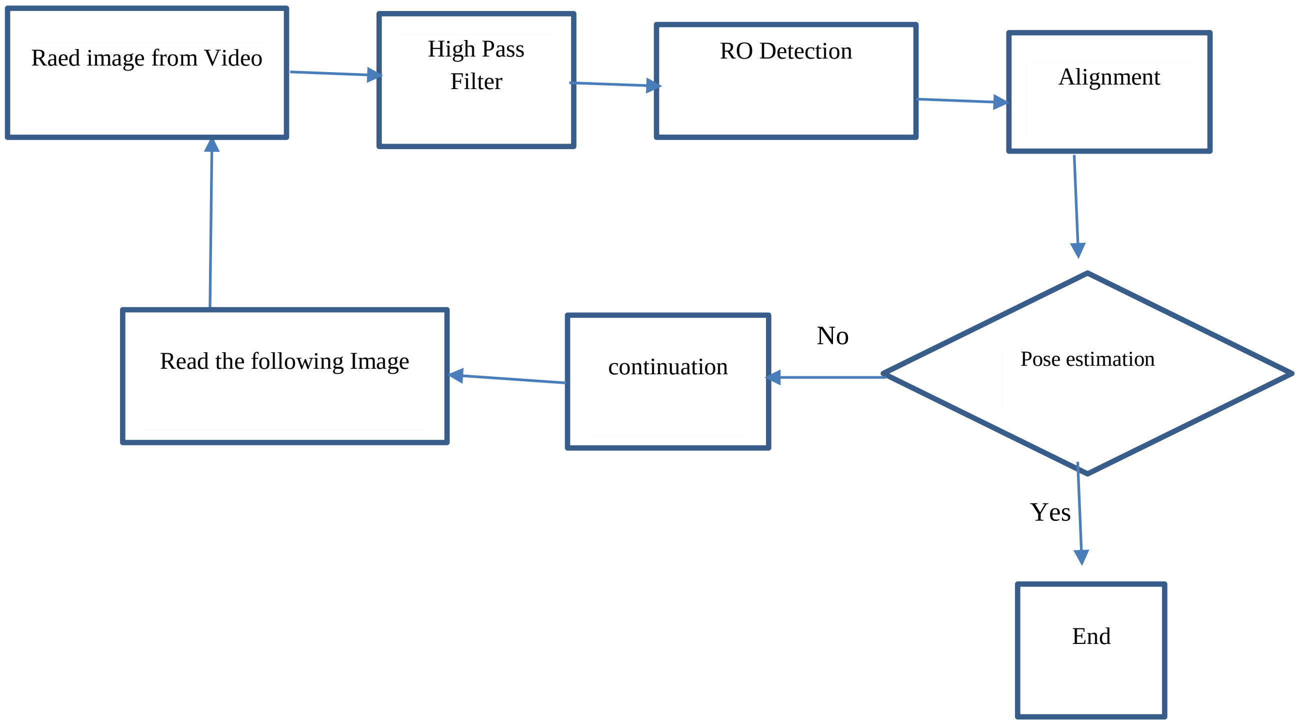

Figure 1: proposal method

4.1 High Pass Filtering

The image has details that correspond to its sequence of the high-frequency component, so pass filtering leads to an increase in the processing sharpness of the image, while the low and high frequency filters facilitate the passage of high frequency and weaken the low frequency. The image has an edge and details located in the high-frequency part, due to the weakness of its component, so the image appears unclear, but through the high-pass filter, we rid the image of noise and highlight the edge to contribute to filtering and smoothing the image [20,21]

4.2 The Detection Phase

Utilizing geometric transformation principles as well as common interest features, the detection process's primary goal is to precisely determine an object's position within frame as well as its rotation. Two images—the first video frame and the reference image—are inputs to the detection process, which outputs a matrix of parameters of transformation (M). The virtual object is imposed into a video frame during the detection step using a Reference image, which is a representation regarding the real object that is identified in the video frame. For detecting and recognizing object position within a frame, the reference image as well as video frame's interest features are typically extracted. Harri's Corner Detector is used to identify the interest features, resulting in two feature sets. Real object's rotation within the video frame is represented by the transformation parameter matrix (M), which is found using matching characteristics. Matrix (M), which will be utilized throughout the alignment procedure, will be regarded as the crucial information for the following steps. Additionally, a Reference Transform is recorded for the matrix (M). The precise position of the real object in the video frame is determined during this stage using the matching features. Real object position in the video frame will be predicted by identifying the matched point in the reference image with max. Y, max. X, and the matched point with min. Y, min. X.

4.3 The Alignment Phase

A real object and a virtual object are aligned in a certain position within the frame during this stage. The real object's rotation and position are fed into this step. In order to generate a registered frame as the output, it performs the procedure of the alignment between real and virtual objects in designated rotation and location. Three tasks must be completed by the alignment stage:

1 To make the virtual object the same size as the real one, resize it.

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2 Converting the virtual object to match the real object's rotation.
3 Making sure the virtual and real objects are aligned correctly.

A function that scales the virtual object to the size of real object was built in order to make the virtual object's size proportionate to real object's size. This function determines the virtual object's proper dimensions and scales it. The virtual object's new dimensions are established using the scaling factor. The scaled virtual object must be adjusted to match the real object's rotation in the video frame following being resized to match the size of real object. The scaled virtual object is changed by parameters of transformation (M) in the alignment stage to create the new virtual object. Through precisely aligning virtual object position with the real object, the virtual object will then be put into the video frame.

4.4 The Continuation Phase

We have applied the KLT method to monitor the movement regarding real object in video frames. KLT algorithm's major goal is to determine the position related to key points in the 2nd frame given 2 frames from a video and a certain selection of those points in primary frame. Two video frames are fed into the tracking stage, which outputs a new matrix for transformation parameters (M). The information of real object within the new video frame is represented by this transformation matrix (M). There are three basic steps in the tracking stage:

1. Determine whether the position of the real object has changed across the frames. KLT method was utilized to identify such changes.
2. To identify the new rotation regarding the new video frame, estimate the parameters of geometric transformation between those two video frames.
3. To get the transformation parameters between the current and first video frames, add up the geometric transformation.

The key points that will be tracked by the KLT algorithm throughout the entire video frames must be chosen before applying the method. KLT algorithm detects the new position regarding the real object by tracking such important points in the current frame in addition to its position in the subsequent frame. Accurate selection of such key points is necessary for effective tracking, hence the matching features of the 1st video frame (i.e., the Master Features) were chosen as the tracking key points. Though the location of these important points may vary with each video frame, at initially they accurately depict the real object's position in the first frame. KLT algorithm determines locations of important points in the current frame and looks for those same key points in subsequent frame. The real object's rotation in new video frame, indicated by Tracking Transform, is represented by the matrix of transformation parameters (M), which is produced by implementing the geometric transformation between the two video frames with the use of 2 sets of the tracked key points. This completes the process of tracking that is related to the real object in the new video frame. Although real object's new rotation and position in the new video frame are precisely recognized at this point, the information can' be considered sufficient to be employed in the procedure of alignment. The stage of tracking must therefore be aware of the real information of transformation between Reference image and real object in current video frame. It is necessary to perform an accumulative operation of the parameters of transformation between the transformation parameter of the first video frame (i.e., Reference Transformation) as well as transformation parameter of tracking key points (Tracking Transform). The real object's transformation parameters in every new frame are determined by the original reference transform and the transformation of its preceding frames in such cumulative process.

5 RESULTS AND PERFORMANCE

The procedure of alignment between two objects (virtual and real) is implemented into video frames by the second suggested approach (FIOA). Using attributes extracted from video frames, this technique can identify the location of real object and follow its movement throughout entire video frames. This technique registers a real object invariant location into video frames using several virtual objects. To investigate the efficacy of the FIOA approach, three tests were conducted.

5.1 Feature Extractor

Three different feature extractor types were tested on the Chrisbrown video sequences for determining the impact regarding the feature type of extractor vof the suggested approach (FIOA). Test's results are summarized in Table 1.

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Table 1: The Performance of FIOA utilizing Three Feature Extractor Types

Extractor name	SSIM	TRE	RMSE	TIME.SEC
Fast	0.982184	0.00177682	0.0146821	1.22677
SURF	0.983183	0.00278002	0.0549614	1.34741
Harris	**0.984154**	**0.000103142**	0.**00107566**	**1.17821**

It is clear from Table 1 that the Harris Corner Detector takes less time to implement and is becoming more accurate than other varieties.

5.2 Transformation Type

Three different transformation types—similarity, affine, and projective—have been used to investigate how the kind of transformation affects FIOA approach's performance. Affine transformation has produced superior outcomes when compared to the other types of transformation, as demonstrated by the data in Table 2.

Table 2: The Performance of FIOA Approach with the use of 3 Geometric Transformation Types

Trans.type	SSIM	TRE	RMSE	TIME.SEC
Projective	0.927069	0.00211357	0.0197461	2.62672
Similarity	0.0193118	0.00258906	0.0193118	2.86739
Affine	**0.985064**	**0.00010342**	**0.00106336**	**1.28950**

5.3 Fioa Performance

Five 100-frame video sequences were used to test the FIOA approach; Table 3 provides a summary of the findings.

Table 3 : The Performance of FIOA Approach with the use of Five Video Sequences

Video Sequence	SSIM	TRE	RMSE	TIME.SEC
Monstersinc	0.880396	0.00147944	0.01384590	1.40658
Computerarch	0.984084	0.00107474	0.04440489	1.55073
Otomatatheory	0.984995	0.000359602	0.00616881	1.55669
Barrywhite	0.956374	0.000375376	0.956374	1.21117
Chrisbrown	**0.984153**	**0.0001049457**	**0.00107568**	**1.16765**

6 CONCLUSIONS

One of the most important AR aspects is image alignment. The problems with the alignment process are addressed in this study. These suggested fixes were successful in resolving the issue of alignment process delays while also achieving high accuracy and reliability. The following could be determined by putting the suggested approaches into practice: Accurately identifying an object's position throughout the alignment process is crucial since any error could result in obvious misalignment and impact the entire alignment system. More precise object position detection results from the combination regarding the feature-based detection method with the color conversion procedure. Additionally, employing a precise and efficient method to monitor changes in the object's position guarantees constant access to the precise location of the object. Based on the results, FIOA outperformed the other two ways in terms of accuracy, and the suggested techniques satisfied a greater accuracy level when compared with the conventional method. TRE and RMSE values obtained by the Real-Virtual Object Alignment approach are 0.00107566 and 0.000103042, respectively.

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