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View management approaches for labelling in Augmented Reality: A survey

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ABSTRACT

Augmented reality consensuses with coexisting appearance of real world with virtual objects in same space. It is a vital aspect of Human Computer Interaction. View management techniques in augmented reality predominantly emphasizes on efficient representation, optimal layout and temporal coherence strategy of annotations with respect to 3D objects to avoid obstructions, clutter and depraving effectiveness. Limited update rate in view/ layout leads to showcase annotations in more composite manner. According to the variation in applications of augmented reality, labelling one or more view management approaches can be used. Change in view point and corresponding change in the amount of information of annotations is the focal motivation of this survey paper. Three view management techniques, Viz. a) Image driven view management technique deploying saliency algorithm and edge map, b) User driven view management technique based on layout algorithm and adaptive rendering for altering background features , c) Geometric feature driven view management technique are reviewed and a review analysis is presented.

Keywords: augmented reality, Annotations, view management technique

1. INTRODUCTION

An emerging use of computer and networks that connect them face challenges with its vast data, as efficient data accessibility and representation. Information related to 3D objects, it becomes overhead to the user with complexity of querying procedure. Hence, to exploit and utilize potential of computers, real world is enhanced with some additional information, which is known as 'Augmented Reality'. Augmented reality deals with computer into reality of user rather than replacing it withvirtual environment [1]. One of the applications of augmented reality is to enhance camera feed with related information. For example, one can point smartphone camera at an object (e.g. monuments) and system will display information related to respective object. AR is not limited to the sense of sight but also deals with touch [2], sound [3, 4] and hearing [5]. Collectively AR incorporate display devices (technologies) to represent real and virtual world, sensors to track user or system's position, user interface technologies that allow real time orientation and 3D interaction [6].Most eminent practical applications of augmented reality technologies areeducation [7, 8], manufacturing [9, 10, 11], construction [12, 13], entertainment [14] and transportation[57]divulges great prospectiveforhumanizingpredominanttechnological aspectsandextension to eminence of life.

HoloLens and *Google Glass* are categorized as a virtual reality as well as an augmented reality device. HoloLens is made advanced as its headset recognizes the wearer's choral communication, eye movement, and hand gestures to interact collectively with virtual and real world. Applicability ranges from corporate remote communication to hands-free work environments [15].

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In this paper,among all above wide range of AR applications, we emphasis on study of real world envisioned objects and respective annotations.Annotations are used to enhance visualized objects and metainformation. They occur in various forms like labels, symbols [4] and 3D geometrics [13, 14]. Meta graphical objects (connecting lines, anchor points) are used to relate visualized objects and textual labels. Web based annotation tools such as Xspect [15] andOpen hypermedia systems include Devise Hypermedia [16]are examples of AR annotation based systems.However, primitively placing annotations generally leads to occlusion, clutter and vitiating effectiveness of 'Augmented Reality Visualization' [17]. To resolve above issues, many view management techniques have been proposed [13, 19,20]. These annotations can be placed in two ways either directly on the surface of objects they refer to i.e. internal labeling or outside object of interest and draw 2D line to its center.

*View management is*a technique of maintaining visual constraints on the projections of objects on the view plane by preventing objects from occluding each other.In this, dynamic labeling management is essential to address above problems by following measures of adaptive and structured label placement, view-driven label ûltering and label searching [21]. Adaptive label placement can be achieved by determining a suitable region, displaying the position of objects and evaluating background of label layout styles [14, 21].

2. RELATED WORK

It is indispensable to go through various aspects of AR labelling, methods of label placement and issues and to optimize these snags selecting proper view management approach is obligatory. Large Majority of view management algorithms focused on managing virtual contents andcreating comprehensive layouts.

2.1. Augmented reality labelling

AR enables little resemblance to the actual tasks in the real world and can superimpose 3D virtual objects on real-time videos [22]. The combination of mobile-based tracking system, wearable devices [52, 55] and context-aware computing techniques, Web based annotation systems can be used to develop applications to collaborate physical world with digital information[23].

2.2. Issues in labelling and layout

Azuma et al. in [24] evaluated a novel algorithm based on identifying existing clusters for label placement, which is quick and prevented overlap between labels.In [14], there are many layout algorithms are introduced. In non-interactive cartographic applications, labels are placed according to point, line and area features [25]. Jason et Al. have used camera tracking to find dark and uniformed regions so that it becomes possible to move text (labels) from one location to another most viable location to exploit readability [17]. Texture properties and visual features are used to predict text placed on particular location would be readable at some extent [26].Feiner and Doree [27] introduced group of algorithms to maintain visibility constraints to identify obscuring objects and render them according to the updates in viewing specifications.Penalties such as overlapping, line orientation and edge map are minimized in order to avoid overlying annotations, occlusion with object and to keep annotations consistent in sequential frames [28].

2.3. Prominence of view management approaches

Many view management approaches focus on improving content readability and visibility [29]. Distractions caused by changes between two viewpoints (old and new) can be reduced by creating temporally coherent layout using approaches like 'minimally different neighbors' and 'minimize potential distractions' [19]. 3D occlusions can be avoided by controlling viewing specifications of selected object [30, 31]. Bell et al. in [32] suggests that layout of previous frame can be used to identify occupied and unoccupied space by object where labels deprived of occlusions can be placed. Context aware view management technique can deal with multiple dynamic situations so prior knowledge of the scene is not required [33].

There is significant difference in task performance of presenting object labels in object space or image space. Limited update rate is required if annotations are presented in object space [6]. Image space approach has been proposed to evaluate force field in every frame in order to update label layout accordingly. Frequent force field changes in every frame in dynamic environments tends to ailment of jumping labels [34]. Less visual interest areas are recognized by using feature density. By using this information it is possible to compute label layout [27].View management system for augmented reality should be able to display annotations coherently, as the view point changes.

3. ANNOTATION NOMENCLATURE

Hansen [23] provides survey of annotations in augmented reality with respect to web pages, ubiquitous computing and virtual reality.

Our understanding of AR annotations is:

Annotation in augmented reality is an information of an 'object' that represents its either one or more (varies according to application requirement) constituent like description, category, history and current state.

History: The concept of labelling was firstly introduced in cartography; Imhof [35] in 1975, stated that good name or label position represents clarity and discernibility. In addition, each name or label in map should have only one optimum position. Direction of lettering, type spacing, colors and letter overlapping aspects are significantto achieve better legibility [35]. This practice of label positioning has come in to clear picture with modern technologies and systematic label placement approaches for augmented reality.

Types: Different types of annotations are used in variety of forms within different application domains such as advertising, gaming and labelling of individual parts of 3D objects [28, 36].

3.1. Spatially dependent or independent annotations

Spatially dependent annotations have to be registered to world coordinate system as well as respective object. These annotations are required to have spatial relevance to user's environment e.g. MuseumTour [37]. Spatially independent annotations does not required to have same texture as an object but in some way it must be adding (information) or changing real world e. g. *PokemonGo(game)*can be played anywhere as per user's location [38].

3.2. Environment centric or user centric annotations

Environment centric annotations have strong relationship between content and surrounding location e.g. Building information. There is strong relationship between user and content in user centric annotations. They are mostly used for communication purpose and content is location independent e.g. application of speedometer indicator [17].

3.3. Internal or External Labelling

These are two label placement approaches. Internal labels and external labels have their own advantages and disadvantages. Internal labels are convenient for label overlapping handling as they are placed inside objects boundaries projection. An arrow or a single line is used to connect label (placed out of object boundary) and respective object. External labels can reserve the appearance of object from being assorted but difficult to maintain unambiguity [39, 21].

3.4. Annotation Immovability

Annotations may not always visible. The reason behind hiding them is to avoid threat of occlusion and overhead of contents. Limited presentation of annotations make it easy to determinewhich annotation belong to which object. Jason et al. in [38], found four different permanence strategies that allows the most relevant labels to be visible. These four strategies are*temporally controlled, spatially controlled, user controlled* and *information filtered permanence.*

3.5. Label layouts and challenges

All layout specific algorithms such as *Radial layout, Ring layout* or *Flush left right layout, Silhouette-Based algorithm* prevent label overlaps and intersections of connecting lines to make it more compact [14]. The most commonly used comprehensive algorithm for label layout of single frame are as follows:

Algorithm Steps:

1. Analyze an image (feature, edge map etc.).
2. Determine positions of anchor points.
3. Identify empty space regions and image analysis (unoccupied space by object).
4. Allocate empty space regions.
5. Determine label styles and permanence strategy.
6. Compute preliminary label layout.
7. Eliminate overlaps and resolve line intersections.
8. Improve readability and layout densification.

All label layout algorithms rely on anchor points.

Anchor point: *Distance function* is applied to compute internal pixel of segment of an object. For every pixel distance, function computes its distance to the segment boundary and stores value in *distance image*. Mask is placed on *distance* image and highest distance value is returned as *anchor point* [14].

3.6. Challenges

The label layout in interactive real time AR system probes additional requirements such as frame-coherency and efûciency that can be achieved by considering interaction context and user specific requirements [40].

1. Readability: If there is lack of enough space provided by area and object features, then opting for external labelling will be more coherent. In many AR applications, annotations are presented according to user's point of interest. Readability is subjected to text drawing styles, image polarity and background. It is recommended to choose proper font, light text on dark background, use mixed case, avoid flashing and scrolling text [21, 41]. Text legibility is dependent on contrast ratios i.e. contrast ratio between the label text and the drawing style as well as drawing style and thebackground [53].
2. Frame coherency:To preclude visual discontinuities during user interactions in dynamic environments the representation of identical layout elements between subsequent frames have to be minimized [42]. Minor changes in object may affect on consistency also minimum displacement between anchor points and connecting lines should be there.
3. Compaction: This is an issue of minimizing the area or the total edge length of the layout [43].
4. Unambiguity:Linkage between objects and labels are easily recognizable as it prevents referential mismatches. In addition, salient regions are used to place internal labels that reside within object's

interior.External labels should be placed nearer to object and least number of bends in connecting lines [41].

5. AestheticConsiderations:Label layout should be neither too scattered nor too compact in order to achieve symmetric distribution of labels and aligned horizontal or vertical with respect to one another [41].

4. VIEW MANAGEMENT TECHNIQUES

View management is used to attain uniform integrationofadditional2Dinformation (images, texts, annotations) into the view plane. Majority of view management algorithms attempt to minimize occlusions of annotations with respect to objects. It is necessary to identify user viewed objects and their annotations that highlights overlapping between viewed object and real objects [54]. Some of them helps in avoiding overlapping and improving readability. Viewability varies according to environmental changes such as indoor, outdoor, day and night (lighting conditions) etc. [42]. Excessive changes in current and new viewing angle and viewing position rise many problems like loss of context and loss of orientation [43].

4.1. Image- Based View management Technique

Common augmented reality applications of labelling directly put the labels at the end of point of interest of an object. An adaptive view management (without scene knowledge) focuses on:

1. Minimum interference with real world information.
2. Background management to make labels more readable.
3. Approach to maintain frame coherent labels.

Image based approach has been introduced to overcome many problems of augmented reality applications, to improve visual quality of annotated object and designed for producing static images. This approach automatically adapts representation of labels from video frame information to improve contrast. A better approach for image space label placement can be achieved by storing label positions relative to the projection of anchor point. Anchor point supports the user in identifying the real position of point of interest [19].

According to the camera movement, anchor point needs to be reprojected in image space in every frame, so that label drift problem can be solved (Naive label updates and reuse of label position from previous frame leads to positional drift) [6].

Different label layout approaches are as follows:

Planar separation: Azuma's cluster-based label placement technique [24] employed for planar label separation. In planar separation (Fig. 1.),visual overlaps are managed in 2D view plane by moving labels in any radial direction (circular direction by considering a central point of object) around the object [45].

Naïve method: This label layout produced in a style which deliberately rejects sophisticated representation and lack of superiority with no perspective [45].

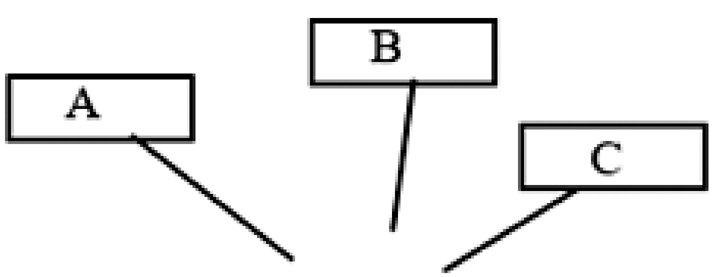

Figure 1: Planar Separation

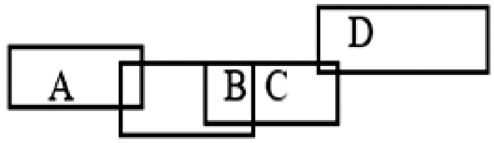

Figure 2: Naïve Method

*Height separation:*This label layoutmove labels in heightabove the object by means of managing overlaps. It simply performs a single iteration from the default label placement [45].

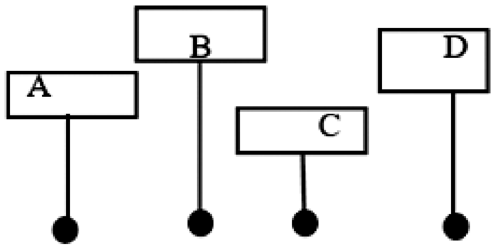

Figure 3: Height Separation

Depth separation: Labels are moved in perpendicular view plane to avoid overlaps. Thses labels are sorted according to distance between lable and object in current frame. Overlap chains describes path of continual overlaps.

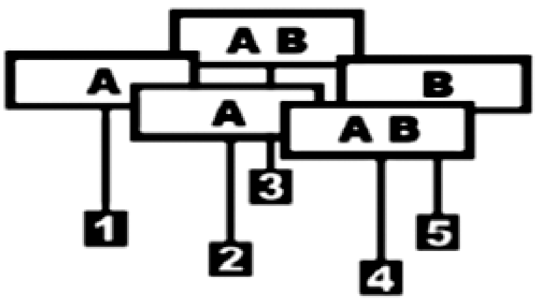

Figure 4: Depth Separation

Image based approach analyses current video frame in real time, *Saliency map* and *Edges map.*Combination of these maps leads to identify comprehensive descriptionof the scene such as important image regions and geometric constraints for layout optimization and label placement [45].

Saliency map: Salient image region detection is useful for applications such as object segmentation, recognition and compression. *Saliency detection algorithm* proposed in [14] is used to make norms about scale of the object. This object detection is based on its position in an image by using low level features of color and luminance.

Edges map: The purpose of detecting sharp changes in image brightness is to capture important changes in properties of the frame. The edges can be classified as either viewpoint dependent or viewpoint independent. A *viewpoint independent edge* typically imitates essential properties of the three-dimensional objects. A *viewpoint dependent edge* may change as the viewpoint changes and reflects the geometry of the frame scene, such as objects occluding one another [46].

Augmented reality environments are highly unpredictable and dynamic in nature. To avoid distracting layout changes view management algorithms must employ temporal coherence.Camera motion, Shaking hand approach and Object motion has taken into consideration with hysteresis based approach [13].

4.2. User Driven View Management

This is user driven approach hence focuses on improving user's feeling of engrossment towards information representation on AR based application.More precisely it derives solution to layout management issues with efficient utilization of available viewing layout and contrast and color tuning [23].AR based labelling application demands information for each point of interest, name, GPS coordinates, category and ephemeral description which is stored in database.

Following two methods are mainly used in this view management approach:

Layout algorithm: Layout algorithm aims to set user's view position to avoid overlapping. Generalized layout algorithm [47] consists three steps: 1) Analysis: Scene analysis is essential in order to identify available space and user's preferences. 2) Classification: Determining layout of placing external labels but if sufficient space is not available better to opt for internal labels. 3) Placement module determines remaining layout specific parameters.

Adaptive rendering: To reduce burden of rendering method, insignificant spaces that user is not focusing are identified [45].

Illumination parameters of an image are computed in order to change color, contrast to improve label readability over background. When user is moving, AR based system constantly analyzes the movements and after filtering out small changes, it checks if user position remain constant. Small changes are filtered and condition is verified that user orientation is being constant. Augmented Reality application sends to remote service (database) a request containing following elements[20].

1. Illumination Information(camera/user's current real world view)
2. Point of Interest(Chosen by user)
3. GPS position(User)

Ray casting technique can be used to check overlapping POIs. While displacing a virtual POI from original position, identification of real position of POI can be done by using anchor point and leader line information. To improve readability can be improvedand high background brightness avoided. [20].

4.3. Geometric Feature Specififc Approach

Force field based 2D view management techniques are able to generate high quality layouts but dynamic (camera) movements leads to suffer from floating labels [51]. In 3D labels as placed relative to the anchor point in object space. Object space algorithms can control fluxes by switching from continuous to a discrete layout update strategy [39]. When the user changes view point, the labels remain temporally coherent, so it is necessary to change label orientation in every frame. Unpredictable changes over time in real time systems where distribution of projected 3D points changes during camera movements. View management approach plays vital role of frequently re-ordering of external labels.View management approach [13] in 3D space consists two phases:

Initialization phase: In this phase, 3D labels are placed for each element, anchor point calculation for each object segment and determining orientation and length of leader line. Certain amount of spacing is maintained between annotations to avoid overlapping.

Update Phase: To minimize occlusion this view management approach allows searching suitable positions for annotations within entire frame. This approach supports discrete update strategy. Annotations are updated only of angle between view vectors annotations increases beyond threshold value otherwise freezing of annotation layout is opted [13].

3D view management approach in object space applies changes to the layout based on 3D geometry of the label. Here, layout strategies operating on 3D object space approach is used, so the stacked layout problem is solved [39].

5. Comparitive study of View Management Techniques

Table 1
Feature based analysis of different view management approaches according to issues.

	View management approaches		
Observed parameters	*Image driven*	*User driven*	*Based on Geometric features*
Readability	Salient image region detection	Contrast and saturation tuning	Parallax effect
Adaptedtechniques (label placement)	Label layout (height and planar) separation approach is used to avoid label to label overlapping.	Adaptive rendering algorithm is used to avoid object and label overlapping.	Plane based approach is used to repositionof labels to avoid stacked labels.
Frame coherency	Label shift problem is solved in adjacent frames.	Label displacement according to user's POI.	Discrete update strategy with freezing orientation of labels.
Legibility	Greedy algorithm and force based algorithm is used.	Improve user's feeling of immersion by adding animated annotations.	Force based layout to maintain spacing between labels.
Label layout	External labels	Animated annotations	External labels
Object detection	Saliency map and edge analysis	User's POI using maximum distance boundary approach.	Center based 'hedgehog' approach
Temporal coherence	Label movements are avoided if small changes in scene	No specific approach is used for temporal coherence in AR.	Labels move around 3D poles.

6. CONCLUSION

We have reviewed image driven, user driven and geometric feature specific approach as different view management approaches. Comparative study in Table. 1. states that,these view management approacheshelps in selecting one or more techniques according to different application specific requirements like object detection, label layout and frame coherency etc.In addition, they have different levels of proficiency to deal with 'temporal coherence' and other similar issues caused by excessive changes in current and new viewing angle and viewpoints. It is necessary to improve label readability and information representation after generating label layout. These all improves efficiency, user's satisfaction and engrossment towards AR based labelling system.

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