

Parametric Analysis of Fixations During Object Search using AI

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ABSTRACT: The movement of eyes while looking at visual stimuli is termed as scanpath. One of the major components of scanpath is fixations. The analysis of fixations could provide understanding about individual's area of interest and behavioral pattern. One of the prominent domains of fixation analysis is object searching amidst surrounding distractions. Fixations have generally been analyzed in terms of parameters. In this paper two parameters of fixations have been analyzed during two experiments of object searching. The parameters have been termed as number of fixations and total fixation duration. The results indicate that fixation parameters are impacted more when objects have been searched in images with low color variations than with multiple object content.

1. INTRODUCTION

The analysis of movements of eyes has been a prominent research area. Eyes represent non verbal medium of communication that could potentially provide information about analytical processing of brain. The visual tendencies and preferences of individuals can be inferred from the movement of eyes [1, 2]. The analysis of eye movement data has been a part of various domains that include therapeutic, assistive technologies, game development, object searching and marketing strategies [3, 4]. Many advanced head attached and remotely capturing equipments with processing software have been implemented for detection and analysis of eye movement data [5]. While visualizing a scene or searching for objects, eyes follow a path termed as scanpath [6]. Looking at any area of visual scene for a certain period of time during the scanpath is termed as fixations. The process of fixations has been vital information for understanding human tendencies towards different visual objects. The scan pattern during searching of objects has been understood through analysis of fixations [7, 8]. The analysis of fixations has been generally performed in terms of fixation parameters. The most commonly analyzed parameters have been 'number of fixations' and 'total fixation duration'. In this paper the two identified fixation parameters have been analyzed during two experiments of object search. During the process of object search, a target object has to be identified among a group of distractions. The distractions can be in the form of low color variation, identical target and non target objects, presence of edges and presence of multiple heterogeneous objects [11, 12]. In this paper result of two experiments on the fixation parameters have been discussed. In the first experiment a total of ten subjects have been instructed to search for specified objects in two images. In the second experiment thirty one subjects have participated in the experimentation. The reason for increasing the number of subjects has been due to inconclusive result for 'total fixation duration' during experiment one. The method of eye movement detection and subsequent analysis has already been discussed in [13]. In the next section a discussion on work related to fixation parameters has been put forth.

2. Related Work

Many researchers have suggested a correlation between content of visualized scene and fixation parameters. The difficulty in searching for an object is directly related to presence of distractions in the presented images [14, 15]. One of the procedures for quantification of impact of distractions in a scene on eyes is through parameters of scanpath. The parameter 'number of fixations' suggest total number of times eyes looked at different regions in the presented image for a certain period of time. The parameter is calculated for each experiment. The parameter 'total fixation duration' calculates the cumulative time taken for all the fixations during each experiment. Many researchers have suggested that high number of fixations and higher duration of fixations indicate towards difficult object searching procedure [16, 17]. The researchers have also linked higher number of fixations and higher duration of fixations to image content of presented images being relevant and interesting [18, 19]. However many studies have also found that higher value for duration of fixations might indicate easy target search as more and more objects have been identified during the fixations [19]. The fixation duration

of individuals has increased during less visibility of target objects [18, 20]. Some authors have also put forth that difficulty in finding the target object might not impact duration of fixations [21]. In the previous work presented by authors in [13], it has been found that number of fixations has been higher for image with low color variation than image with presence of multiple objects. However the result for parameter ‘total fixation duration’ has not provided any definite results. In the present experiment the comparative analysis of two identified fixation parameters during two experiments of object searching has been put forth. The results obtained have been discussed in section IV. In the next section methodology of the current experiment has been explained.

3. METHODOLOGY

In this section a discussion about experimental structure in terms of subjects, setup and images utilized has been put forth. A brief discussion about eye movement detection and analysis system has also been put forth.

Subjects

During experiment first a total of ten subjects participated. During experiment two a total of thirty one subjects participated for object searching in two presented images. The age group of subjects ranged from 21 to 45 years.

Setup

A digital camera has been placed on a tripod at a distance of 50 cm (L1) from the subjects. The distance between camera and screen has been set as 200cm (L2). The resolution of camera used has been (4592x3056) with 1.42 megapixels. The camera had a frame rate of 25fps. The subjects had to rest the face on a chin rest. The screen dimensions have been kept as 158X252cm² (L3xH1). The distance parameters between screen, camera and subjects have been placed in an order that could ensure efficient detection of eye movements. Fig. 1 presents a description about placement of subjects, camera and screen along with dimensions of the screen.

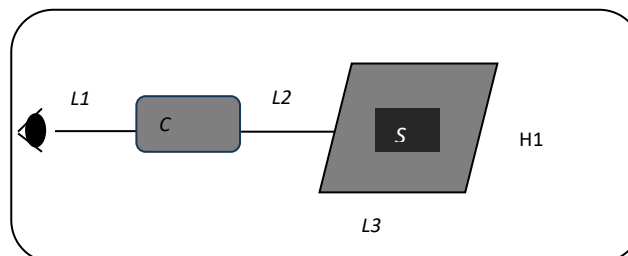


Figure 1. Experimental setup during object searching investigation. L1=50cm, L2=200cm, L3=252cm, H1=158cm

Images Used and Process Sequence

Two images have been shown to subjects one after the other in a sequence. The subjects have been shown first image and instructed to search for a board with ‘Thank You’ written on it. The image represented visual scene with presence of multiple objects other than target object. Once the target object in first image has been found the subjects have been instructed to close their eyes that marked end of first object search. In the next image the subjects had to search for the presence of ‘parrot’ in the all green background. The image represented visual scene with low variation of color. Fig.2 presents a snapshot of images shown to subjects one after the other. The objects to be searched have been encircled in Fig. 2 (c) and Fig.2 (d). The source of images has also been provided.



Figure 2. Images a) (@Wegmans on twitter via Business Insider) and b) (www.artwolfe.com) have been shown to the subjects in sequence. The objects to be found have been encircled in c) and d).

Detection and Analysis System

Many algorithms have been implemented for detection of various eye features and generation of results. Voila jones algorithm has been implemented for eye detection followed by algorithm of circular hough transform for iris detection. Different vectors and matrices have been created for storage of different results during processing of data. The detailed description of all the techniques has been already explained in [13]. Fig. 3 presents a general overview of different stages required for final generation of analytical data.

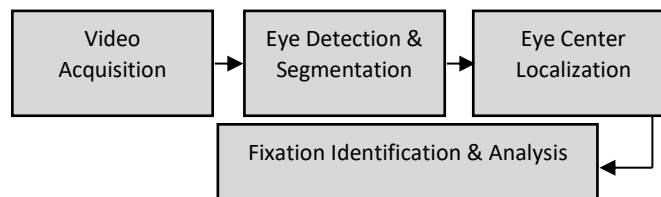


Figure 3. Sequence of processes involved for parametric analysis of fixations

In the next section a discussion on results generated has been put forth.

4. RESULTS AND DISCUSSION

During experiment one, the values for parameter ‘number of fixations’ and ‘total fixation duration’ for all the ten subjects have been calculated. The values of identified parameters have been calculated during target object search in both the images. Table 1 presents the result of parameters ‘number of fixations’ during target object search in first image and second image. The result of ‘number of fixations’ parameter for ten subjects during target object search in first image has been represented by ‘N1’ in Table1. During target object search in second image the parameter of ‘number of fixations’ has been labeled as ‘N2’.

Table 1. Result of parameter ‘number of fixations’ during first and second image object search. The obtained values for first image and second image object search have been labeled as ‘N1 and ‘N2’ respectively.

Subjects	N1	N2
Subject1	28	36
Subject2	02	05
Subject3	04	04
Subject4	03	07
Subject5	12	10
Subject6	03	05
Subject7	12	19
Subject8	07	08

Subject9	08	08
Subject10	05	09

The results in Table 1 indicate that the parameter of ‘number of fixations’ has been higher during search of ‘parrot’ in all green background in comparison to search of ‘Thank You’ board in first for all the ten subjects. Only one subject out of ten subjects i.e. subject 5 showed results otherwise. The results for subject 5 have been highlighted in Table 1. The results in Table 2 presents the result of parameters ‘total fixation duration’ during target object search in first image and second image. The result of ‘total fixation duration’ parameter for ten subjects during target object search in first image has been represented by ‘T1’ in Table2. During target object search in second image the parameter of ‘total fixation duration’ has been labeled as ‘T2’.

Table 2. Result of parameter ‘total fixation duration’ during first and second image object search. The obtained values for first image and second image object search have been labeled as ‘T1 and ‘T2’ respectively. The values represent time duration in seconds (s).

Subjects	T1(s)	T2(s)
Subject1	13	15
Subject2	05	04
Subject3	05	07
Subject4	04	04
Subject5	06	04
Subject6	06	02
Subject7	07	10
Subject8	06	05
Subject9	03	03
Subject10	03	05

As shown in Table 2, the results for ‘total fixation duration’ for first and second image show no conclusive outcome. The difference of values has been very low besides no majority of resultant values for target object search for first and second image has been obtained. The cumulative average of the parameter ‘number of fixations’ also indicates higher value during object search in second image as compared to first image (Fig. 4). The cumulative average for ‘total fixation duration’ during first and second image object search show negligible result as indicated in Fig. 4.

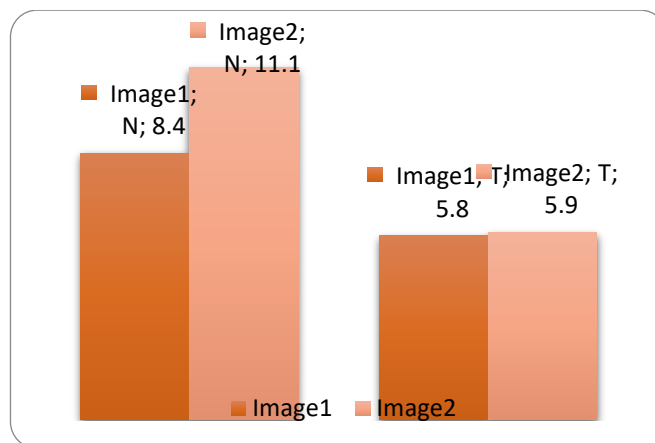


Figure 4. Cumulative results for ‘number of fixations’ and ‘total fixation duration’ during object search for first and second image. The parameter of ‘number of fixations’ has been represented as ‘N’. The parameter ‘total fixation duration’ has been represented as ‘T’.

Given the number of subjects being only ten, the authors repeated the experiment by increasing the number of subjects. A total of thirty one subjects agreed to participate in the experiment of object searching in the presented images. Fig. 5 presents the generated result for parameter ‘number of fixations’ on thirty one subjects.

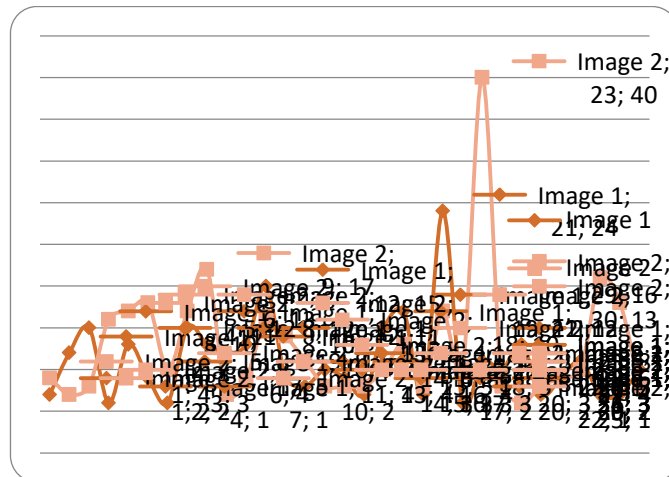


Figure 5. Result of parameter ‘number of fixations’ during object search in first and second image. The data is of thirty one subjects.

The results indicate a total of seventeen subjects have higher value of ‘number of fixations’ during object search in second image. A total of fourteen subjects indicated towards higher value of parameter ‘number of fixations’ during object search in first image. For the parameter of ‘total fixation duration’, the values have been plotted in Fig.6 shown below. The values plotted are for object search in first and second shown images. As is shown in Fig.6 eighteen subjects out of thirty one subjects exhibit higher value for parameter ‘total fixation duration’ during object search in first image. A total of thirteen subjects exhibit higher value for parameter ‘total fixation duration’ during object search in second image.

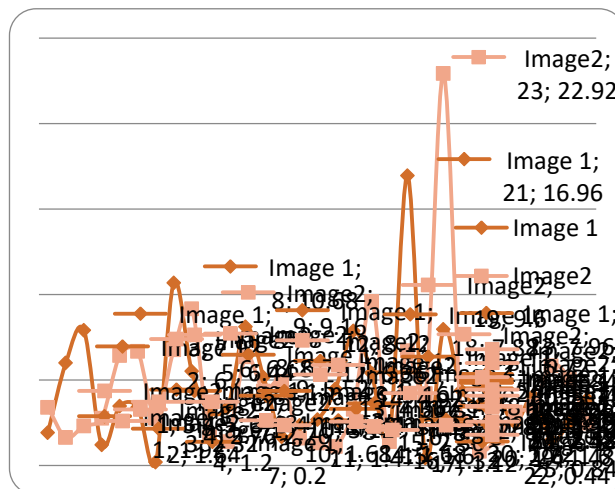


Figure 6. Result of parameter ‘total fixation duration’ during object search in first and second image. The data is of thirty one subjects.

The results on the identified fixation parameters do indicate towards having higher value of ‘number of fixations’ during search operation in second image as compared to first image. Also the results indicate towards lower value of ‘total fixation duration’ during object search in second image as compared to first image. However the difference in number of candidates divided on the final result has not been very high. The cumulative results for both the parameters in Fig. 7 indicate higher ‘number of fixations’ and lower ‘total fixation duration’ during object search in second image. The results point towards the conclusion that images with low variation of color have been harder to process for subjects than images with presence of multiple heterogeneous objects. The results however do not reflect a high marginal difference between the resultant values. The authors suggest increasing the number of images with high similarity between target and non target objects.

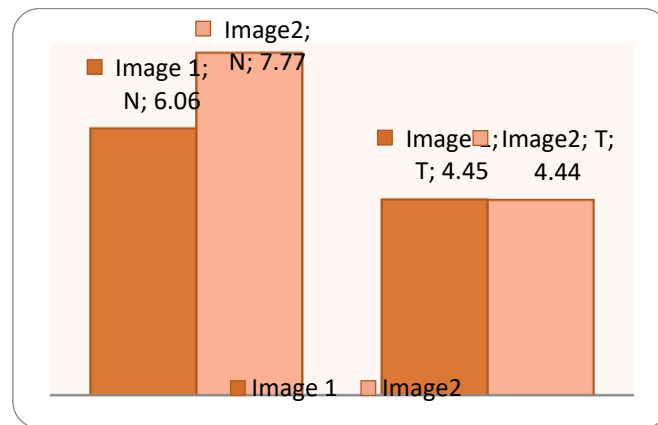


Figure 7. Cumulative results for 'number of fixations' and 'total fixation duration' during object search for first and second image. The parameter of 'number of fixations' has been represented as 'N'. The parameter 'total fixation duration' has been represented as 'T'.

5. CONCLUSION

In this paper an experiment of object searching in two images has been conducted. A total of two experiments have been conducted. In the first experiment analysis of identified fixation parameters for a total of ten subjects has been put forth. The second experiment has been conducted on a total of thirty one subjects. During the experiment higher value for parameter 'number of fixations' has been obtained during object search in image with low color variability. The image with presence of multiple objects in it has shown lower values for parameter 'number of fixations'. The results indicated towards image with low color variation hard to process than image with multiple object presence. However the result of parameter 'total fixation duration' has been inconclusive during first experiment on ten subjects. The authors stressed upon increasing number of subjects that could present a definite result for parameter 'total fixation duration' as well. The results during experiment second do indicate towards higher number of fixations and lower duration of fixations for second image in comparison to first image. However the difference in number of subjects having difference in values between object search for first and second image has been low. Also the observation by different researchers for parameter 'total fixation duration' has been contrasting. As explained in section of related work, some authors suggest lower value of 'total fixation duration' during difficult object searching and some visa versa. Therefore the authors suggest increase in number of parameters for analytical study. Also the authors suggest increasing the number of images with variation in content. The content variation could be in terms of high target distracter similarity.

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