Illustrative Halos in Information Visualization

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ABSTRACT

In many interactive scenarios, the fast recognition and localization of crucial information is very important to effectively perform a task. However, in information visualization the visualization of permanently growing large data volumes often leads to a simultaneously growing amount of presented graphical primitives. Besides the fundamental problem of limited screen space, the effective localization of single or multiple items of interest by a user becomes more and more difficult. Therefore, different approaches have been developed to emphasize those items – mainly by manipulating the items size, by suppressing the whole context or by adding supplemental visual elements (e.g., contours, arrows). This paper introduces the well known illustrative technique of *haloing* to information visualization to address the localization problem. Applying halos emphasizes items without a manipulation of size or an introduction of additional visual elements and reduces the context suppression to a locally defined region. This paper also presents the results of a first user-study to get an impression of the usefulness of halos for a faster recognition.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*evaluation*; H.5.0 [**Information Interfaces and Presentation**]: General

General Terms

Design, experimentation, human factors, verification.

Keywords

Illustrative rendering, illustrative visualization, halos, information visualization.

1. MOTIVATION

An important problem in interactive scenarios is the fast localization of relevant information to effectively perform a task. Especially in cases where large amounts of information are scattered loosely on the screen, the search time may increase immensely if no localization supporting system is provided.

In information visualization – where interaction is a principal component – the visualization of permanently growing data volumes is a general aim. In many cases, this visualization results in an increased amount of visual primitives. An effective localization of interesting items becomes hard to achieve without any support. Therefore, different methods have been developed to emphasize interesting items. Accentuation techniques like the magnification of the interesting item [3] or indicative contours or arrows are explicitly emphasizing the wanted information. Suppression techniques like desaturation, transparency or hiding of unimportant items [5] reduce the visual presence of distracting visual primitives and therewith implicitly emphasize the remaining. In [11] a brief overview over several emphasizing approaches in medical visualizations is given. However, the existing strategies bear constraints: Both, accentuation and suppression, are endangered to occlude, distort or simply hide surrounding context information – that may be crucial for the interpretation of the interesting information – if applied inconsiderately.

Although the illustrative technique of haloing is a wide spread tool in graphical applications (Sect. 2), it is rarely considered in information visualization. Therefore, this paper analyzes the usefulness of halos to accelerate the localization in interactive scenarios like information visualization scenarios. We use a simple halo-generator (Sect. 3) to produce haloed images that are also used in a user study. The result and the design of this study are presented in Section 4. The results of our work are discussed in Section 5.

2. RELATED WORK / BACKGROUND

Graphical halos originate from artistic drawings to highlight important persons and to enhance the visual separation of objects from the background. This is done by drawing the surrounding background locally with brighter or darker colors. In that way, the contrast is locally adapted and therewith halos support the human viewing process [10]. The spectrum of halo effects ranges from thin gaps around the highlighted object through thick opaque outlines up to nearly undistinguishable darkening or brightening effects.

Today halos are used in different domains. For example in medical illustrations halos are used to enhance the perception of depth and the distinction of different structures. Moreover, many approaches have been developed in the field

AVI'08 , 28-30 May, 2008, Napoli, Italy

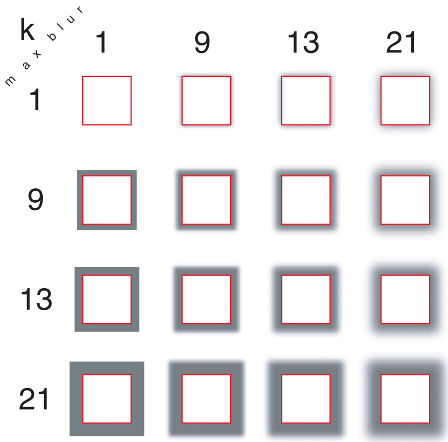

Figure 1: Black halos with different k_{max}, k_{blur} and a transparency of 50%.

of 3D visualization and 3D rendering to achieve an enhanced depth perception. Very early a first method has been developed to improve the perception of overlapping lines in 3D [1]. Halos are also a wide spread approach to distinguish different structures in the field of flow and volume visualization. For example in [7][8] they are used to visually separate different stream lines within a 3D flow visualization. Approaches from volume visualization [4][13][2] and 3D rendering [9] often result in interactive GPU-based methods. The use of halo profile functions in [2] additionally allows an effective definition and manipulation of halos.

The fast access to import information in complex information spaces is a main aspect in many efficient work scenarios. Therefore, several techniques have been successfully developed to emphasize screen elements. However, these techniques (see Sect. 1) manipulate the presentation of visual attributes and therewith may hinder an effective interpretation of data values. Other visual clues may occlude important information. Moreover, some of the existing techniques are simply not applicable in every scenario. Contour lines for example cannot be applied if the highlighted object itself is a thin color encoded line due to misinterpretation risks. Applied to pixel oriented visualization techniques they would occlude information.

The examples from flow and volume visualization show that halos are widely used for a better distinction of *all* different structures [7][8][4]. In some cases, they are already used for *accentuation of single objects* [2]. However, up to now halos are not sufficiently considered in information visualization. A first approach that uses halos in the field of *2D information visualization* is presented in [14]: Thin outlines are used to enhance the perception of line based visualizations (parallel coordinates, network visualization). For this reason, this paper analyzes the benefit in the field of 2D information visualization – especially for localization tasks. The presented study verifies the usefulness of halos.

3. HALO GENERATION

A common approach to generate halos is the use of a seed image combined with a low-pass filtering that blurs the edges. The result is a so called halo field image (see [2]) that is used in the final halo rendering. The naive application of a low-pass convolution to the seed image may blur out halos of small but maybe important visual primitives. In [2] this problem is solved by a multiple use of low-pass filters followed by a recombination with the original seed image.

Figure 2: The halo generation (from left to right): Seed image, enlargement, blurring and compositing.

To generate a wide range of halo effects with low efforts, we use a simple but flexible approach that extends the common one. It uses an additional maximum filtering step to prevent disappearing halos around small primitives and to provide a big variety of halos. The overall halo generation is summarized as follows (see Fig. 2):

1. The object to be haloed is rendered offscreen as a seed image whereas its color values represent the values of the later halo field.
2. A 2-dimensional maximum convolution of free kernel size (k_{max}) is applied to the seed image. A quadratic filter kernel with $k_{max} \geq 2$ enlarges the seed image.
3. A low-pass filter of free kernel size (k_{blur}) is applied to the result of step 2 to get a soft-edged halo. We use quadratic filter kernels with Gaussian weights.
4. The gained halo field is used to render a halo that is combined with the remaining visualization.

The free combination of k_{max} and k_{blur} allows the generation of outlines ($k_{max} \geq 2, k_{blur} = 1$), the prevention of disappearing halos ($k_{max} = k_{blur}$) or a simple blurring of the seed image ($k_{max} = 1, k_{blur} \geq 2$). Figure 1 shows the influence of different k_{max} and k_{blur} to the halo appearance.

The first three steps result in a halo field image containing values that may be interpreted in different ways. A common way is to interpret the halo field as alpha values of a colored halo. More complex halo profile functions are also possible (see [2]). The transparency (values of the seed image) and the color of the halo become additional parameters which can be used during application. These parameters control the conspicuousness of the generated halo as they influence the appearance (color) and contrast to the background (color and transparency).

The wide range of different halo effects described here, enables the support of different localization tasks. *Directed search* for example, means the fast localization of one or a small set of visual primitives as the result of a concrete query. In many cases of information visualization this is important for efficient task performance. For example one or more items of interest shall be compared to the whole information space and should therefore be located fast. For example color coding is used in Figure 3 to visualize health data of ≈230 districts of northern Germany in January 2000. The number of respiratory infections recorded by a health insurance is visualized. Since color coding is good for perceiving the global value distribution and maximum values,

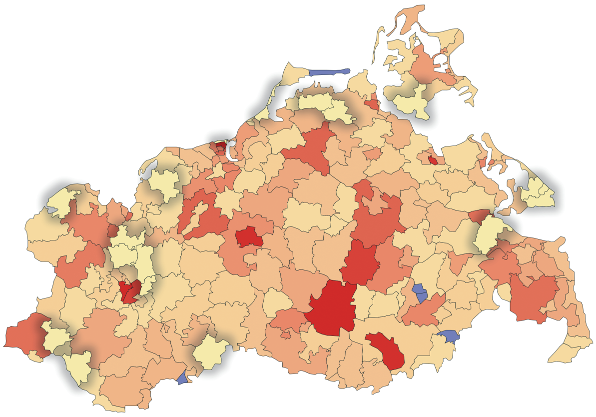

Figure 3: Color coded respiratory infections in northern Germany. Highlighting halos are applied to districts with minimum values. These areas are easy to perceive, although color is more prominent.

it is hard to distinguish lower values. Therefore halos are used to highlight minima. Although the red areas are more prominent, the districts with lowest values are easy to perceive.

Additionally, halos may also support the *undirected search*. In this case, a data set is explored without any concrete query. Thus, halos should not be used preeminent to highlight single items of interest but in a subliminal way to support the general exploration. For example, statistical features concerning the data may be mapped onto halo parameters to control the items visual prominence.

4. USER STUDY

Since halo outlines are nearly equal to contours (e.g., see [12] [14]), this paper considers only halos with a blurred edge ($k_{blur} > 1$). Moreover, we concentrate on semitransparent monochrome halos to investigate the subliminal use that is often found in artistic drawings. This kind of halo can be seen as a hybrid of accentuation and suppression as it suppresses locally the background (by the transparency property) and accentuates the haloed object (colored opaque property). To verify and quantify the usefulness of such halos in localization tasks, we developed and realized a small uncontrolled user study. The aim of our study was to get a first impression of halo parametrization for an acceleration of the *directed search* on different cluttered backgrounds.

Currently eight female and twelve male participants took part in our study. Their age was 20 to 36 and the education varies from secondary school up to PhD students. Only three persons were educated in computer science.

Design The task that had to be performed by the different participants was a simple search for one given icon within a larger group of 49 shown icons. These were randomly chosen from one of two different sets of 120 icons (color icons and polygon icons). For each set we used three different backgrounds (no, medium, hard cluttered) and four different halos (none, small, medium, large). Colors (in *Lab* color space, see [6]) and icon sizes (const.) were chosen carefully to achieve nearly constant visual stimuli.

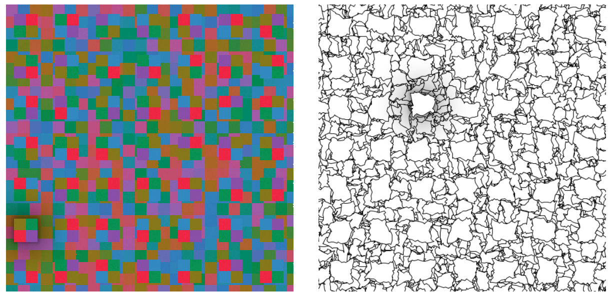

Figure 4: Two example screens of our study: left) a color icon scenario, right) a polygon icon scenario. In both cases, the most difficult background and largest halos were applied.

Procedure This study has been implemented using a web page (*http:// www.informatik.uni-rostock.de/∼malub/ study.html*) to simply address a larger group of participants. To prevent the development of a fixed search strategy, every presented screen has been generated completely randomly (equal distributed pseudo random): the used icon set, the selection of 49 icons, the used background, the used background orientation and the used halo. Participants of the study were briefed by a small text (German) and a monitor calibration image. Afterwards they were exposed to 100 screens containing the randomly generated image and one icon to be found. Clicking the located item loads the next screen and records localization time. Image generation parameters are the only additional recorded values.

Analysis and Results To get a first impression of halo parameterizations and the influence of different backgrounds, a straight forward analysis has been performed: Wrong answers were disregarded and extreme outliers (3∗IQR) were eliminated per participant to get a meaningful average. The overall average suggests that halos are generally able to accelerate the localization process.

Figure 5 shows the average answer times with both kinds of icons on different backgrounds with different halos applied. In the color icon scenario (see Fig. 4 left) we expected the most difficult background to provoke the highest answering times in the unsupported scenario. Instead the medium cluttered background did. This and the seeming faster feedback concerning the medium halo on the medium background compared to the largest halo, may be ascribable to the fact of few participants and the uncontrolled environment. However, the diagram shows that the perception of a halo seems to depend on the halos size and the background: Whereas every halo is hard to perceive at a white background, they seem to be well recognizable at the noisy backgrounds. This may be explained by the halo-introduced increased contrast on a colored background resulting in a better separation. Meanwhile, the halos decrease the contrast on a white background, due to their grey appearance. Although the results of the polygon icons are similar to the color icons, some differences can be found. The most important is the background dependance: The localization task becomes more and more difficult with an increasingly cluttered background (see Fig. 4 right) – even with applied halos. Whereas the contrast is increased in the color icon scenario, now the contrast decreases due to the overlapping of black background lines and a black halo. Therewith the

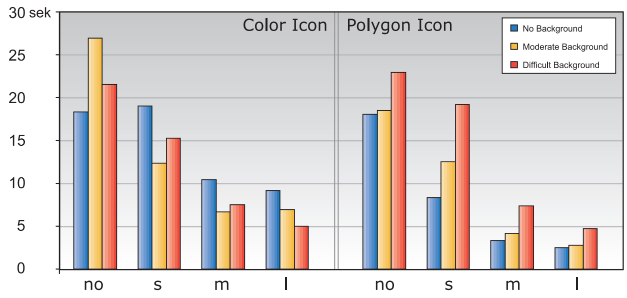

Figure 5: Average localization times achieved in a directed search for a single icon. Different halo sizes (no,s,m,l) were applied on different backgrounds.

halos disappear. However, the applied halos reduce the localization time corresponding to every background.

Due to the low number of participants and their strongly varying localization times, no heavy analysis has been executed on acquired data. Besides the decreasing average answering times, a continuous reduction of standard deviation with increasing halo sizes has been observed. The bigger fluctuation found in the color icon scenario may be due to unknown perception malfunctions of the participants and different lighting conditions.

5. CONCLUSION

Our approach of using halos in the field of 2D information visualizations describes an additional way to emphasize items of interest. Many of the several existing accentuation methods to are restricted to tight constraints and therewith hinder an overlapping use of one approach in several visualization techniques. The wide range of parametrization possibilities makes halos very flexible and so they may be adapted to different tasks and visualization techniques. Thereby, the halo effect can be modified continuously from a hard edged opaque outline to nearly invisible soft halos.

The major benefit of halos in information visualization is the naturally provided parameter of transparency. Therewith, halos generally do not occlude context but modify it locally to enhance the perception of selected items. In contrast to known suppression techniques, the global overview is preserved. In Figure 3 for example, the minimum values are perceived at first glance without any occlusion or graphical distortion. Hence, halos support the exploration of large data volumes and represent an non-opaque alternative to distortion and information hiding techniques. Especially the fast localization, that is often needed in efficient work scenarios, is supported. Moreover, even data values may be mapped on halo parameters.

Since maximum filter and Gaussian blur are separable filters, they can be used each as a combination of two 1D filters. Thus, convolution complexity changes from $O(n^2)$ to $O(2n)$ enabling time critical applications.

Although the implemented study showed that halos are helpful in localization tasks, it also showed that the efficiency of halos strongly depends on the given background, color and transparency. Therewith, similar problems appear that are known from accentuation techniques like contours. Both, color and transparency have to be selected carefully to guarantee an accentuation affect. Different alternatives like a local desaturation of the background using the halo field may cope with that problem.

Therefore, further investigations will examine the use of this compositing alternatives to achieve high contrasts independently of the background. Moreover, further user studies are reasonable to get a more quantitative assessment of halo sizes and to analyze the contribution of transparencies and colors. Different visualization tasks should be investigated. Finally, a direct comparison to contours and other techniques may reveal the limits of our approach.

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