Toward Expanding Visual Experience and Satisfaction of Visually Impaired on Large Screens

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ABSTRACT

In this paper, based on a toy survey result to understand the way of watching televisions or screens of visually impaired, further research subjects for how to expand visual experience and satisfaction of whom has visual impairment are presented.

1 Introduction

Environmental, social, and corporate governance (ESG) factors for globalized companies have been no longer treated as trivial issues [1-3]. Specifically, ESG has become now central term to a companies' reputation. Among the various ESG-related activities of companies, providing appropriate accessibility functions for most of the service and product providing companies is highly recommended recently. Therefore, many giant technology and consumer electronics manufacturing companies have been providing accessibility features on their products recently. Samsung electronics has been also proactive in providing accessibility features in its products [1, 2]. One of them, the App 'SeeColors', co-operated with Budapest University of Technology and Economics, gives some toy survey examples on screen to check color blindness and the type of costumers and adjusts the screen colors for those who have difficulties in recognizing correct or intended colors on screen [1]. Also, Samsung 'Creative Laboratory (C-Lab)' which is In-house venture development program released the service named 'Relumino' [3]. That is a mobile App and virtual reality (VR) solution for visually impaired who has low vision. By running Relumino App after connecting the mobile phone to the VR device, customers with low vision can visual aid for reading characters, seeing fore scenes and watching content.

Most active development of the accessibility features for consumers has been in mobile phone-based service application (App) services and industries [4]. Apps, gears and tools are able to make day life easier for visually impaired people. Specifically, a lot of Apps have been designed to support navigating, reading, enjoying physical activity and watching content. For example, 'Lookout' (Android) provides active feedback by narration about what happening around users by using camera and sensors on a device to recognize text, people and objects.

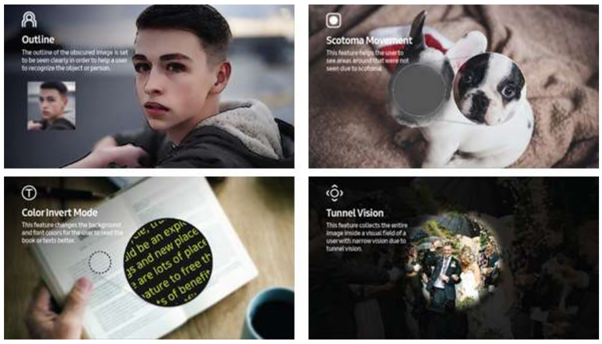

Fig. 1 Visual-aid services on the App 'Relumino', (from left top to right bottom) visibility enhancement, blind spot movement, high contrast for helping read text, image rescaling for the visually impaired with tunnel vision.

'Brighter and Bigger' (Android/iOS) help users who have trouble reading printed text by using camera's light and features adjustable magnification. 'Nearby Explorer' (Android/iOS) App combines GPS navigation for guiding direction turn-by-turn in pedestrian and vehicle modes. These App solutions can expand the consumers' experience in their individual lives.

However, there has not been many researches on technologies for improving visual experience for visually impaired when directly (without any help of aid-devices) watching any content on large displays or screens. Do low vision people always need any type of gears like glasses or head mounted displays (HMD) when watching television (TV)? In their living room, just like ordinary people, how can we expand their visual experience and satisfaction when watching content on large screen without any gears? That is very important question toward finding the most effective accessibility feature. For that, the most and first question can be 'how the people with visual impairment watch TV and enjoy content on screens?' To understand 'how they do?' would let us know the direction of possible visual service using recent technologies on large ultra-high definition screens. This paper consists of two sub-category studies, a small unit survey and discussion with low vision people and our further possible researches to meet our goal.

2 Related Work

There have been many basic researches on improving visual experience of low vision people [5-10]. M. Zorec et al. presented the visual assistant imaging system for visually impaired [5, 9]. The proposed method provides enhancement or adjustment techniques for given image to alleviate their specific eyeball condition and let them to see images more clearly on screen so that it can help them use the most of the residual vision. The system makes people who suffering from vision loss recognize given image or information by uncovering unseen clues such as hidden edges, enriching the image contrast and scales. in the paper [9], an accessible desktop video player software was proposed. The software allows people with low vision to adapt the presentation of digital videos according to their specific needs. For visual enhancement for people who has low vision, the authors implemented a wide range of image processing techniques such as contrast adaptation, color conversion and edge detection for improving visual recognition. In the other perspective, J. R. Ehrlich et al. presented a research on HMD for people who has visual impairment [6-7]. The authors considered many HMD device factors which can be varying by eye-lens configuration to users' eyeball, field of view, ambient lights, capability of color reproduction, pixel resolution, and finally user experience. T. Miura reported very interesting study on how to improve web browsing experience using a screen reader for visually impaired [10]. Their website ad-hoc feature eliminates unnecessary headings, links, and other elements so that visually impaired can read more easily the content. As a result, the function can be effective to shortening of the listening time of the screen reader between keystrokes.

3 Survey and its Results

Recent smart TVs offers new various possibilities of connected services, rich picture quality and color reproduction, interactive features and also accessibility functions. However, we assumed that visually impaired cannot fully use of all those smart features due to their visual limitation. Moreover, it is well known that low vision people are very sensitive to the ambient lighting environment or lights from display screen. So the survey asked participants to let us know 'how they watch TV and enjoy content on screens?' The first section of our survey is just for questionnaire for those printed questions. The second part of this survey is demonstration on TV screen by using aid of 'Relumino' App. The App displayed steaming content that was specifically processed for low vision people and participants see those videos on screen.

3.1 Recruiting Observers (participants)

We requested cooperation to the 'Welfare Institute for Disabled' in Seoul city and recruited 9 persons.

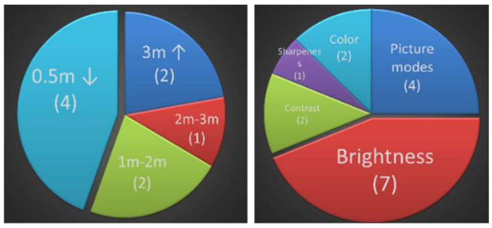

Fig. 2 Survey results on 'How to watch TVs', (left) observers' distance from a screen and (right) most frequently adjusting picture options (multiple choice).

We asked for participants' specific qualifications and the agency recruited participants who met those requirements. We limited to consumers who have the purchasing power to purchase home appliances and who usually enjoy watching TV (more than two hours a day) at home. Their occupations and ages varied, (average was early forty's) and specific observers were excluded such as people who is working display industry, developing visual aid or gears or educated professionally in this kind of survey. Simple information of the participants is listed in the Table 1. The visual characteristics of the recruited participants were not blindness so that they usually enjoy watching TV with residual visual acuity.

3.2 Questioning and Answering

The survey was focused on three things to know as follows. 20 questions about 'how they watch TV under which environment including viewing distance, room brightness and picture options of displays?', 10 questions of 'How they interact with their TV or monitors (tablets)?' and finally 10 questions regarding 'What is the key functions for them just to enjoy content on large screen? This survey included both open- and closed-ended questions. An author of this paper recorded participants' answers by communicating with them to collect their live opinions.

3.3 Results

In this section, most meaningful results of the survey are presented. First of all, to know visible capability of survey participant is important in our survey. Most of the observers have been facing with visual loss that is still in progress. One of them has much residual visual capability than the others so he still can see some details of object on screen. Fig. 2 also shows the result of how far away the observers are when they watching TV or monitors. For the same reason, 'vision loss', they generally watching TV very close to the screen. Many of them, stay less than a meter (< 1m from the screens) to get a better view of the TV content. To see more clearly and enjoy the content, many of them (67%) have been trying to adjust much more often picture options than people without disabilities, as shown in Fig 2.

Table 1. Information of participants

#	Gender	Age	Eye Condition
1	Male	40's	Loss of peripheral vision, blurred vision & red-green color blindness
2	Female	30's	Blurred vision & very sensitive to brightness
3	Male	30's	Loss of peripheral vision & blurred vision (severe)
4	Female	20's	Loss of peripheral vision & blurred vision (specifically severe left eye)
5	Female	40's	Blurred vision for far-field
6	Male	40's	Highly nearsighted & farsighted simultaneously
7	Male	40's	Blurred vision & nearsighted
8	Male	20's	Loss of peripheral vision & blurred vision
9	Female	50's	Loss of peripheral vision (severe, less than 0.01 degree) & blurred vision

Generally, it is known that about 70% of people do not adjust any picture option given in their TV features, even just once. Specifically, they adjusted picture options in the order of brightness, picture mode, color, contrast and sharpness. However, the survey result said that they have been still suffering when watching TV since most of them couldn't find the best fit picture options for them, unfortunately.

At the second part of this survey, we demonstrated the vision-aid features on TV screen by using the Relumino App. Since the App. is designed for low vision people to use a specific gear like a HMD or glass-type device, the vision-aid functions could not perfectly fit for large screen. To collect the subjects' opinion, various streaming content including sports, news, drama and movies were played on screen with a button that can change the on/off state of the feature for low vision people. Although half of the participants (4 among 9) generally satisfied with the edge-enhancing function, there were a lot of negative comments. By hearing about the inconvenience of many visually impaired when they are watching TV or monitors, in addition, we had time to discuss and think about the way we should consider in order to provide an effective device for the visually impaired to help them watch TV.

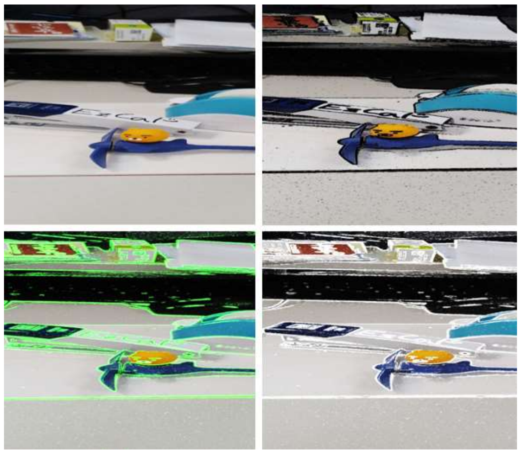

Fig. 3 Demonstration of edge-enhancement feature provided by the App 'Relumino' on TV screen, sample images shown for observers, (left top) original image and edge-empathized images with various (black, green and white) colors.

4 To Expand Visual Experience and Satisfaction of Visually Impaired

With the recent development of deep neural networks (DNN) and its applications, the performance of image enhancement algorithms have been also definitely improved. Specifically, the biggest advantage of convolutional neural network (CNN) is that it can provide optimized and image output for various types of input images [11, 12]. Due to the various types and levels of visual impairment, CNN can be a good candidate that can generate the best-fit image enhancement results for most of individual visually impaired.

For example, many of low vision people often use magnification function on their monitors or smartphones to see more clearly the object in a content. When they want to see some object in content on their screen, however, they magnify the content while stopping playing the content and then resume the content again. This is not an effective user experience for even visually normal people and this kind of usability may cause users' dissatisfaction. Therefore, CNN may solve this pain point for specifically visually impairment. A trained CNN model can detect a salient object in an image or every video frame and then another trained CNN model for immediate magnification for input image can generate magnified outputs. A display system with the CNN models can automatically provide more convenient magnification feature for low vision people.

On the other hand, a DNN model can train users' TV usage habits on picture options (specifically related to emphasis features on improving visibility of objects in input images or video frames) so that it learns preference of picture options for any input image or video classes.

Fig. 4 Demonstrated vision impairments by using low vision simulators of Fork in the Road

The model requires an image classification algorithm or additional CNN model to be trained. Then, the trained model can appropriately render new output image or video frame output with visual-aid features such as color adjustment or edge enhancement based on the viewers' visual conditions like shown in Fig. 3.

5 Discussion and Conclusion

There are many causes that may lead to loss of vision or lead to impairment of vision [13]. For example, from simply injury or infections of the eyes to amblyopia, cataract, diabetic retinopathy, glaucoma and so on. According to these various causes, the types of low visions are also diverse as shown in Fig. 4 [14]. That is why this work has become a challenging situation which cannot satisfy all visually impaired with a specific image processing algorithms. In this paper, therefore, we proposed to use generalized neural network models, which can provide optimized picture option for visually impaired. Expanding visual experience and satisfaction of visually impaired can be started from understanding their visual conditions when watching TV screen at home. For that, to meet visually impaired and hear their voice are the most effective and hence our survey was designed. Under wide spreading of COVID-19, large format experiments or surveys that gather many people are difficult. Although just 9 subjects participated in this time, this survey unit would be revised to improve the content and lasted for our further studies. After the first survey and discussion with the participants, we got several clues on required tech to provide really effective picture services on TV screens.

In this paper, we proposed possible technologies to provide effective picture enhancement options for low vision people by employing CNN architectures. We have been considering CNN-based edge enhancement and salient object-tracking based magnification. As a mid-result of the system, some part of the proposed CNN architecture was built and tested internally. As expected, the CNN based features that was trained using our database look better than any other conventional rule-based algorithms [11].

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