A Children-Oriented Re-ranking Method for Web Search Engines

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Abstract. Due to the explosive growth of the Internet technology, children commonly search information using a Web search engine for their homework and satisfy their curiosity. However, there are few Web search engines considering children's inherent characteristics, e.g., children prefer to view images on a Web page rather than difficult texts. Therefore, general search results are neither friendly nor satisfactory to children. In this paper, to support children to obtain suitable information for them, we propose a method to re-rank a general search engine's ranking according to the children-friendly score. Our method determines the score based on the structure of a Web page and its text. We conduct an experiment to verify the re-ranked results match children's preferences. As a ground-truth, we chose 300 Web pages and asked 34 elementary school students whether these Web pages are preferable for them. The result shows that our method can re-rank children-friendly pages highly.

Keywords: Web search, Children, Re-ranking.

1 Introduction

According to the popularization of the Internet, children are commonly using the Internet for searching information, e.g., using a Web search engine. A survey conducted in 2009 has reported that the number of Internet users of elementary school students has been increasing every year at a rapid pace, and about 90% of 6-12 years old children access the Internet in Japan [11]. Another report investigated the motivations of Japanese children to access the Internet: 53.9% of children use the Internet to search information related to their course works and 53.3% of children search information related to entertainments, e.g., games and sports [5]. These data show that the Internet is a common tool for children to obtain information as the same with adults. This trend brings children opportunities to learn new knowledge much more easily and broadly than past, without being restricted by physical constrains.

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To find information of interest from an enormous pool of information on the Web, it is essential to use search engines. However, there are few Web search engines that considers children's characteristics, e.g., children prefer images and animations to view on a Web page rather than difficult texts. Therefore, many Web pages highly ranked in a search result are difficult to understand or boring for children. For example, general search engines rank Wikipedia (http://en.wikipedia.org/wiki/) pages highly in the search results. While Wikipedia pages are useful for adults since they show a variety of information relating to a (queried) concept in a well organized way, they might not be preferable for children who have difficulty to understand long text with difficult expressions and fewer images. This mismatch between children's characteristics and search engines may discourage children to keep searching information and learn new knowledge. Another remarkable characteristic of children is that they generally browse only top five pages in the search engine's ranking [3]. Therefore, it is important to rank children-friendly pages higher to avoid getting children bored or discouraged.

In this paper, we propose a method that re-ranks a general search engine's result for children. Our target users are elementary school students, who would search information for their homework and satisfying their curiosity. We define children-friendly pages as ones being easy to understand and visually appealing for children. Based on this definition, our method calculates the children-friendly score for each page. More specifically, the children-friendly score is determined based on the structure of a Web page and the text. Then, our method re-ranks a search engine's ranking by sorting the pages according to their children-friendly scores so that children-friendly pages get ranked higher.

To evaluate our method, we invited 34 elementary school children to obtain the ground-truth of children-friendly pages. We chose 300 Web pages and asked the children to judge each of the Web pages based on the three criteria: a) Whether they want to read the page, b) Whether the page is visually appealing to them, and c) Whether the page is easily understandable for them. Based on this ground-truth, we compare our method and commercial search engines.

The contributions of this paper are summarized as follows:

- To our best knowledge, this is the first study that considers children's characteristics on Web search. We thoroughly investigate field studies of children's characteristics on information acquisition and design series of criteria to decide the children-friendly score of a Web page.
- We conducted an experiment to evaluate our re-ranking method with 34 elementary school children. This is one of the largest scale studies with real children. The obtained data would be an insightful reference for researchers working for children oriented works.

The remainder of this paper is organized as follows. Section 2 describes related work. Section 3 explains our re-ranking method in detail; describing features to decide the children-friendly score of a Web page. Then, Section 4 presents the evaluation result. Finally, Section 5 concludes the paper.

2 Related Work

Mima et al. [10] proposed a Web application to support children to search information which is for their study. This application expands a search query based on the ontology that is constructed based on text books for elementary school classes. For example, when a user queries “apple”, this application expands the query to include some related words such as “fiber,” a nutrition of apple. Nakaoka et al. [12] constructed a Web information retrieval system using the ontology for children based on their lifestyles. The children's lifestyle ontology defines concepts related to events for children. For example, it generates a concept of “popular Christmas presents” for an event “Christmas”. This system can guess children's intention on Web search and helps children discover other keywords related to the query.

These applications aim to expand a search query, which is helpful for children to bridge the gap between their intention and the query. However, there is little effort to generate a search result that matches children's characteristics.

In Japan, there have been some search engines targeting children. Yahoo! KIDS [16], which is one of the most popular search engines for children, pushes pre-registered Web pages at the top of a result. These pages are registered by owners (generally commercial companies and organizations) and only those approved through the internal check by the Yahoo! KIDS administrator are presented. The rest of the ranking result is the same as that of Yahoo! Japan [15]. Kids goo [7] filters out Web pages that are judged as harmful for children. The ranking method is similar to Yahoo! KIDS, as it puts registered pages on the top of the search result and other pages follows the original ranking of goo [4].

The main purpose of these search engines is filtering harmful information out so that children can safely search information. Therefore, these search engines' rankings are almost same as that of general search engines. In addition, since the registrations of Web pages, which are recommended to be on the top of the search result, are basically done by adults, these pages are not always children-friendly. Considering that children tend to browse only top five pages of search result's ranking [3], we should highly rank children-friendly pages, which is the main focus of this work.

3 Re-ranking Method for Children

3.1 Definition of Children-Friendly Page

We have thoroughly investigated some conventional field studies on children's information acquisition. Base on the investigation result, we define children-friendly pages as ones that are easily understandable and visually appealing to children. Specifically, children-friendliness is judged from the following factors.

First, we consider whether the structure of a Web page is children-friendly or not based on [1] [3] [6] [8] [13]. While images and animations are appealing to children and support them to understand the contents of a page, children tend to lose their motivation to continue reading when browsing a page that contains densely lined characters. Additionally, when the size of a page is huge and has a lot of information, children get confused since they cannot decide where they should focus. Therefore, a children-friendly page should satisfy the following criteria:

- The page contains images and animations.
- The amount of text is small.
- The number of links is small.
- No need of scrolling.
- Colorful.

Additionally, we consider whether the expression of the text in a Web page is children-friendly or not based on [1] [2] [6] [8] [13]. It is important that the texts in the page are written in a friendly expression for children and easy to understand. Therefore, a children-friendly page should satisfy the following criteria:

- The length of a sentence is short.
- The text doesn't contain difficult expressions.
- The text contains colloquial expressions for children.

3.2 Design of Features

Based on the above definition of children-friendly pages, we set the following ten features on a trial basis. These features are used to calculate the children-friendly score of a Web page in our proposed page re-ranking method. Each feature is normalized to range from − 1 to 1.

3.2.1 Structure Based Features

It is important that the structure of a Web page is easy to grasp the information (contents) for children and also visually appealing to children. Therefore, we set the following six features from the viewpoint of the page structure.

- *Size*

Since children don't prefer to scroll a Web page, a large sized page is not children-friendly. Thus, we set *Size* as a feature which is determined based on the area size of a Web page. $Size_i$ of page i is defined by the following equation, where smaller *Size* means more children-friendly:

$$Size_i = \begin{cases} -1 & (pagesize_i \geq maxsize) \\ -\dfrac{pagesize_i}{maxsize} & (pagesize_i < maxsize) \end{cases} \quad (1)$$

$pagesize_i$ is the area size of page i and *maxsize* is the maximum area size of existing Web pages. Here, we use 1,000×5,000 [pix^2] as *maxsize* based on our preliminary investigation on 1,000 Web pages.

- *Image Rate*

Images and animations are appealing to children and support them to understand the contents. Therefore, we set *Image Rate* as a feature which is determined based on the amount of images and animations in a page. $Image\ Rate_i$ of page i is defined by the following equation, where larger *Image Rate* means more children-friendly:

$$Image\ Rate_i = \frac{\sum_{j=1}^{N} imagesize_j^i}{pagesize_i} \quad (2)$$

$imagesize_j^i$ is the area size of *j*th image or animation in page *i*, *N* is the number of images and animations in page *i*, and $pagesize_i$ is the area size of page *i*.

- *Text Rate*

Children tend to get bored when browsing pages containing a large amount of text. Therefore, we set *Text Rate* as a feature which is determined based on the amount of text in a page. $Text\ Rate_i$ of page *i* is defined by the following equation, where smaller *Text Rate* means more children-friendly:

$$Text\ Rate_i = \frac{-\sum_{j=1}^{N} textlen_j^i \cdot fontsize}{pagesize_i} \quad (3)$$

$textlen_j^i$ is the number of characters in *j*th sentence in page *i*, *N* is the number of sentences in page *i*, *fontsize* is the size of a character, and $pagesize_i$ is the area size of page *i*. Here, for simplicity, we use 16 [point] as *fontstze* for all pages.

- *Link Rate*

Pages that contain a lot of links get children confused since they cannot decide which link they should select. Therefore, we set *Link Rate* as a feature which is determined based on the number of links in a page. $Link\ Rate_i$ of page *i* is defined by the following equation, where smaller *Link Rate* means more children-friendly:

$$Link\ Rate_i = -\frac{num\ of\ link_i}{maxnum\ of\ link} \quad (4)$$

$num\ of\ link_i$ is the number of links in page *i* and *maxnum of link* is the maximum number of links for all existing Web pages. Here, we use 300 as *maxnum of link* based on our preliminary investigation on 1,000 Web pages.

- *Component*

A component is an information block of the relevant information in a page. Children tend to get confused when a Web page contains a lot of components, i.e., the page contains a large amount of information. Therefore, we set *Component* as a feature which is determined based on the number of components in a page. We assume that components are extracted using the method proposed in our previous work [9]. $Component_i$ of page *i* is defined by the following equation, where smaller *Component* means more children-friendly:

$$Component_i = \begin{cases} -1 & (num\ of\ comp_i \geq maxnum\ of\ comp) \\ -\dfrac{num\ of\ comp_i}{maxnum\ of\ comp} & (num\ of\ comp_i < maxnum\ of\ comp) \end{cases} \quad (5)$$

$num\ of\ comp_i$ is the number of components in page *i* and *maxnum of comp* is the maximum number of components in a page for all existing Web pages. Here, we use 20 as *maxnum of comp* based on our preliminary investigation on 1,000 Web pages.

- *Color*

Children tend to prefer colorful pages. Therefore, we set *Color* as a feature which is determined based on the number of different colors in a page. $Color_i$ of page i is defined by the following equation, where larger *Color* means more children-friendly:

$$Color_i = \frac{num\,of\ color_i}{maxnum\,of\ color} \tag{6}$$

$num\ of\ color_i$ is the number of different colors in page i and *maxnum of color* is the maximum number of different colors. Here, we set $1{,}670 \times 10^4$ as *maxnum of color*, which is the maximum number of different colors available for JPEG images.

3.2.2 Text Based Features

As features based on text of a Web page, we set the following four features.

- *Children Expression*

Children are more familiar with colloquial expressions rather than formal ones. Therefore, we set *Children Expression* as a feature which is determined based on the number of colloquial expressions in the text of a page. For this aim, we have constructed a dictionary of colloquial expressions for children by extracting frequent terms from Web pages targeting children, such as Yahoo! KIDS and Kids goo. $Children\ Expression_i$ of page i is defined by the following equation, where larger *Children Expression* means more children-friendly:

$$Children\ Expression_i = \frac{\sum_{j=1}^{N} num\ of\ childexpr_j}{num\ of\ term_i} \tag{7}$$

$num\ of\ childexpr_j$ is the number of occurrences of jth colloquial expression in the text of page i, $num\ of\ term_i$ is the total number of terms in the text of page i, and N is the number of occurrences of unique colloquial expressions in the text of page i, i.e., the number of unique terms that match with colloquial expressions in our dictionary.

- *Difficult Expression*

Children cannot understand difficult expressions. Thus, we set *Difficult Expression* as a feature which is determined based on the number of difficult expressions in the text of a page. For this aim, we have constructed a dictionary of difficult expressions by extracting frequent terms from Web pages featuring news and technical contents. $Difficult\ Expression_i$ of page i is defined by the following equation, where smaller *Difficult Expression* means more children-friendly:

$$Difficult\ Expression_i = -\frac{\sum_{j=1}^{N} num\ of\ diffexpr_j}{num\ of\ term_i} \tag{8}$$

$num\ of\ diffexpr_j$ is the number of occurrences of jth difficult expression in the text of page i, $num\ of\ term_i$ is the total number of terms in the text of page i, and N is the number of occurrences of unique difficult expressions in the text of page i, i.e., the number of unique terms that match with difficult expressions in our dictionary.

- *Easy*

The difficulty of the entire text (not only difficult terms) is also an important factor that contributes to the children-friendliness. The lower the text's difficulty, the more easily children can understand it. Therefore, we set *Easy* as a feature which is determined based on the difficulty of the text in a page. The difficulty of a text is evaluated by the tool proposed in [14] that estimates the difficulty level by using texts extracted from textbooks for elementary school, high school, and college course works. $Easy_i$ of page i is defined by the following equation, where smaller *Easy* means more children-friendly:

$$Easy_i = -\frac{level_i}{maxlevel} \quad (9)$$

$level_i$ is the difficulty level of the text in page i. We set 13 as *maxlevel*, which is the maximum difficulty level in the tool [14].

- *Sentence Length*

A long sentence is difficult for children, since its grammatical structure is more complex. Therefore, we set *Sentence Length* as a feature which is determined based on the average length of sentences in a page. $Sentence\ Length_i$ of page i is defined by the following equation, where smaller *Sentence Length* means more children-friendly:

$$Sentence\,Length_i = \begin{cases} -1 & (average\,len_i \geq maxlen) \\ -\dfrac{average\,len_i}{maxlen} & (average\,len_i < maxlen) \end{cases} \quad (10)$$

$average\ len_i$ is the average length of all sentences in page i and *maxlen* is the maximum length of a sentence for all existing pages. Here, we use 100 as *maxlen* based on our preliminary investigation on 1,000 Web pages.

3.3 Steps of Re-rank

Based on the features described in Section 3.2, our proposed re-ranking method calculates the children-friendly score of a Web page as following steps.

(0) A user issues a query.
(1) Obtain, the search results from a general search engine.
(2) Discard, harmful Web pages for children from the result.
(3) Calculate, the value of each feature for each page in the result.
(4) Decide, the children-friendly score by summing the values of features.
(5) Re-rank, Web pages in the result by sorting them according to their children-friendly scores in descending order.

Since our proposed features are independent from the query, the steps (2) to (4) can be performed offline when a search engine crawls and indexes Web pages.

4 Evaluation

In this section, we present an evaluation we conducted to verify how search results re-ranked by our method match with actual children's perspectives towards Web pages. We examine the effectiveness of each of all features as well as their combinations.

4.1 Ground-Truth Dataset

To evaluate our method, we need a ground-truth dataset that shows actual children's perspectives towards Web pages. Therefore, we have constructed the ground-truth dataset as following steps.

First, we chose six popular queries for children (global warming, service dog, game, horoscope, winter solstice, and Karuta (a traditional Japanese card game)) to collect Web pages to re-rank. These are chosen from top ten popular queries on Yahoo! KIDS during the period between December 2009 and March 2010.

Next, on each query, we collected top 25 Web pages separately from the search result rankings by Yahoo! Japan and Yahoo! KIDS. Since Yahoo! KIDS ranks pre-registered pages on top of its ranking, resulted Web pages are different from Yahoo! Japan and Yahoo! KIDS.

We asked 34 children of six to twelve years old to judge whether collected Web pages are children-friendly or not. To investigate multiple aspects of children-friendly pages, we prepared three different questions for the children. We carefully determined these questions so that children can easily and intuitively answer the questions, which is important to achieve consistency among answers. Specifically, we asked children to browse each Web page with the corresponding query for about 30 seconds, and then select Yes/No to the three questions; “Do you want to read this page?”, “Do you think this page is visually appealing?,” and “Do you think this page is easy to understand?”.

As a result, we collected 1,634 answers in total, i.e., each page was judged by six children on average. We calculated the average vote for each Web page to obtain ground truth ranking of Web pages by regarding 'Yes' as a vote to the page. Here, we define “average vote” as the ratio of number of votes for a page to the total number of children who judged the page. We ranked Web pages separately for above three questions by sorting pages according to their average votes in descending order. If two pages tie, we keep the original ranking order by Yahoo! Japan or Yahoo! KIDS. As a whole, we have 36 ground truth rankings (6 queries and 3 judgment criteria on Web pages obtained by 2 search engines).

4.2 Performance Metric

We used *NDCG (Normalized Discounted Cumulative Gain)* as a performance metric. *NDCG* measures the quality of the search result ranking when the ground truth ranking has cumulative score on a query. *NDCG* at rank k on a query is defined by the following equation:

$$NDCG@k = \frac{1}{IDCG}\left(rel_1 + \sum_{i=2}^{k}\frac{rel_i}{\log_2 i}\right), \tag{11}$$

where rel_i is the relevant score of ith page (in our case, it corresponds to the average vote) and k is the rank. We set k to 5 because children tend to browse only top five ranked pages. *IDCG* is the ideal score of *NDCG*, i.e., the *NDCG* value when sorting pages according to their average votes.

4.3 Results

In this section, we compare our re-ranking method with rankings of Yahoo! Japan and Yahoo! KIDS. We should note that Yahoo! KIDS tends to have a higher NDCG value than Yahoo! Japan, since it ranks pre-registered pages (which are regarded to be worth presenting to children) on the top of the ranking, although the rest of the ranking is the same as that of Yahoo! Japan.

4.3.1 Re-ranking Using a Single Feature

Fig. 1 shows the average NDCG value of our re-ranking results when using a single feature on the Yahoo! Japan dataset and that of Yahoo! Japan ranking. Fig. 2 shows the result on the Yahoo! KIDS dataset together with the average NDCG value of Yahoo! KIDS ranking.

Regarding question (a) (Do you want to read this page?), as Fig. 1(a) and 2(a) show, although the NDCG value on *Size* was 2% lower than that of Yahoo! Japan and Yahoo! KIDS, the NDCG values on the other features were 1% to 14% higher than that of Yahoo! Japan and Yahoo! KIDS. Especially, *Text Rate*, *Color*, and *Children Expression* archived a big improvement, i.e., 7% to 18% higher than the NDCG values of Yahoo! Japan and Yahoo! KIDS. This result shows that children tend to prefer

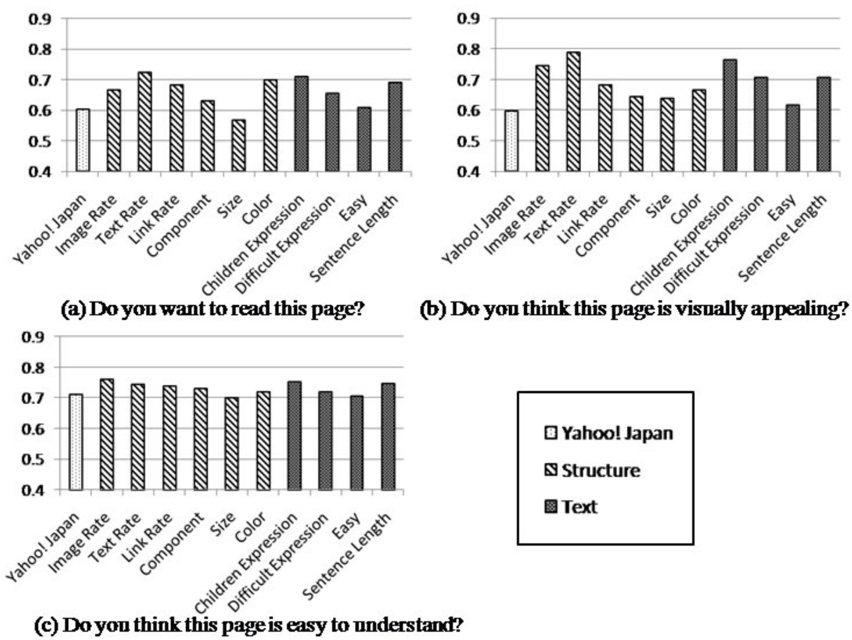

Fig. 1. NDCG of Yahoo! Japan ranking and our method using a single feature

pages that have colorful appearance and contain a smaller amount of text which is full of colloquial expressions. Regarding *Size*, its poor performance comes from the fact that children didn't want to browse too small pages in some cases, i.e., too less contents do not attract children. On the other hand, we observed that a lot of children didn't want to browse pages that are several times larger than the screen size (e.g. Wikipedia). These facts suggest us to appropriately set *maxsize* and extend our method to filter out both too small and too large pages.

Regarding question (b) (Do you think this page is visually appealing?), as Fig. 1(b) and 2(b) show, the NDCG values of all features were 2% to 20% higher than that of Yahoo! Japan and Yahoo! KIDS. *Image Rate* and *Text Rate* especially achieved a big improvement, as 5% to 18% higher than that of Yahoo! Japan and Yahoo! KIDS. This result also supports the result for question (a), as children tend to prefer pages containing a lot of images and lesser amount of text.

Regarding question (c) (Do you think this page is easy to understand?), as Fig. 1(c) and 2(c) show, the NDCG values of all features were 0% to 5% higher than that of Yahoo! Japan and 1% to 6% lower than that of Yahoo! KIDS. This result comes from the fact that pages that explain the contents relating to the query in detail by using both images and text were easy to understand for elder children, but only images are not enough for them. Therefore, we should extend our method to determine the score of each feature based on children's age, e.g., larger amount of text is not always worse for elder children.

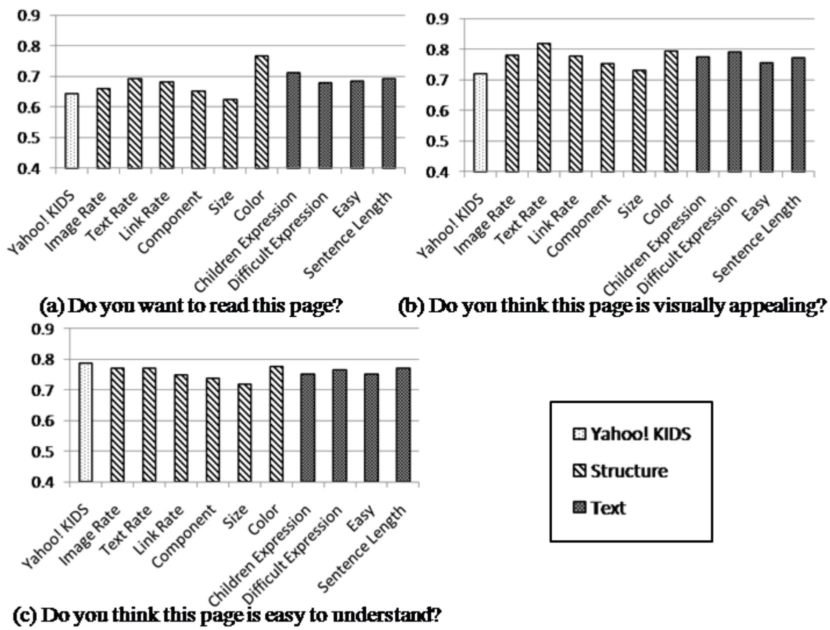

Fig. 2. NDCG of Yahoo! KIDS ranking and our method using a single feature

Additionally, we can see that features that are effective for re-ranking are different among questions. The structure of pages such as the amount of images and text should be taken into account for all questions. On the other hand, the text of a page should be taken into account for questions (a) and (c). As for question (c), we should take into account not only difficulty of the text but also the amount of text according to children's age.

4.3.2 Re-ranking Using a Feature Combination

Next, for each question, we picked the top four features that achieved the highest NDCG values in the results described in Section 4.3.1 and examined the effectiveness of using the combination of the four features. Here, the score of the combination was defined as the sum of the scores of the four features. Table 1 shows the combinations of the four features for each question; *mix1* for question (a), *mix2* for question (b), and *mix3* for question (c). Fig. 3 shows the average NDCG values of re-ranked results using

Table 1. Combination of features.

Type	Equation	Explanation
mix1	*Text Rate* + *Color* + *Children Expression* + *Sentence Length*	For question (a) (Do you want to read this page?)
mix2	*Image Rate* + *Text Rate* + *Color* + *Children Expression*	For question (b) (Do you think this page is visually appealing?)
mix3	*Image Rate* + *Color* + *Children Expression* + *Sentence Length*	For question (c) (Do you think this page is easy to understand?)

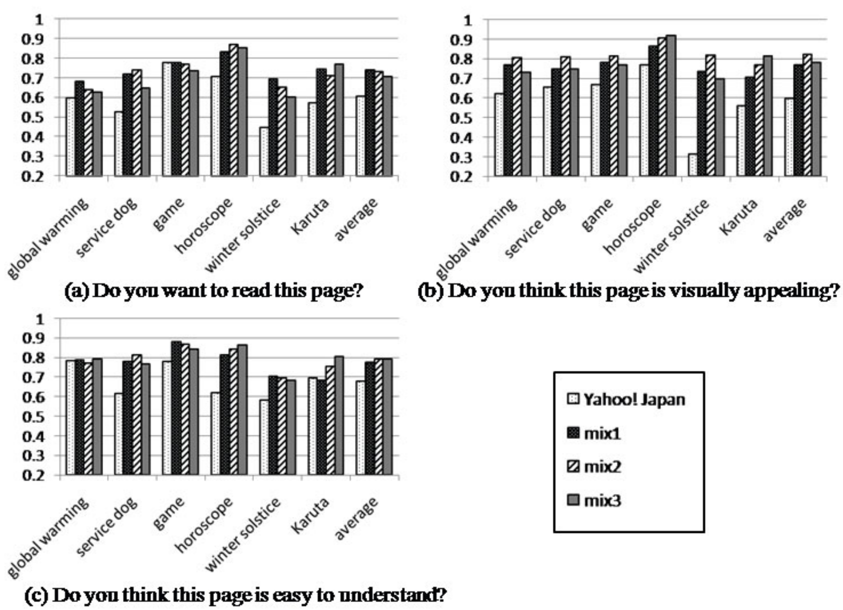

Fig. 3. NDCG of Yahoo! Japan ranking and our method using feature combinations

feature combinations and that of Yahoo! Japan ranking. Fig. 4 similarly shows the average NDCG values compared to Yahoo! KIDS.

These results show that the NDCG values using feature combinations outperform that of Yahoo! Japan and Yahoo! KIDS in most cases. Thus, we can confirm that combined features leverage with each other and improve the ranking quality.

Table 2 shows examples of re-ranked results using feature combinations when the query is “winter solstice”. We can see that children-friendly pages get ranked higher than Yahoo! Japan ranking.

Fig. 3 and 4 also show that queries affect the re-ranking quality. We should take into account the characteristics of queries when deciding the combination of features:

- Queries related to entertainment, such as “game” and “horoscope”, tend to be difficult to commonly provide a good feature combination for all children since individual child has a strong and different preference to such entertainment contents. For example, in our experiments, most boys did not like Web pages related to fancy characters and they judged these pages as low. Therefore, for queries related to entertainment, we should combine features based on individual preferences as well as children's age and gender.
- As for queries unfamiliar with children, such as “service dog”, Fig. 3(a) and 4(a) show that the NDCG values of *mix2* were highest among all combinations. This is because *mix2* prioritize on the amount of images, and thus pages with full of visual contents were ranked higher, which helped children to learn new knowledge. This confirms us that we should use features relating to Web page visuals for unfamiliar queries to children.

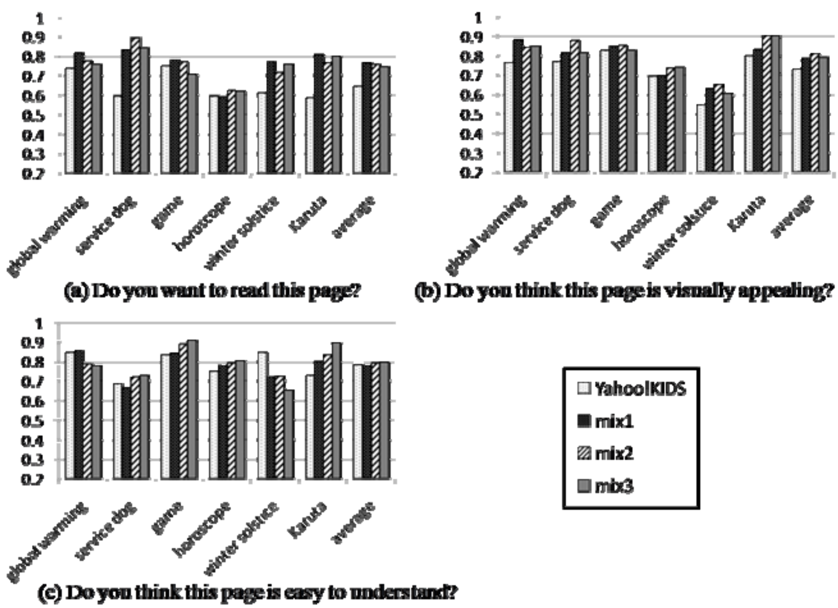

Fig. 4. NDCG of Yahoo! KIDS ranking and our method using feature combinations

- As for query "winter solstice", Fig. 3(c) and 4(c) show that the NDCG values of all combinations were lower than that of Yahoo! Japan and Yahoo! KIDS. Web pages collected by querying "winter solstice" contain both children-oriented educational pages and general pages explaining about "winter solstice" (easy for adults). However, elder children regarded both types of pages as easy to understand, which is the reason of the bad performance in our method. According to our observation, this is because the logical structure of these pages was simple and children regard them easy to understand. Therefore, we should take into account whether the logical structure of the page is simple or not, even for general adult-oriented pages.
- As for queries familiar with children, such as "global warming" and "winter solstice", Fig. 3(c) and 4(c) show that the NDCG values of all combinations were lower compared with other queries. This is because they learn information relating to these queries in their classes, thus, presenting too simple and easy Web pages was not effective. This is confirmed by the result that *mix1*, which does not consider the amount of images, had higher NDCG value than other combinations. Web pages containing large amount of images and animations but not enough text explaining the contents are not preferable for children. These results confirm us that we should use features relating to text of a Web page for queries familiar to children in their classes.

Table 2. Examples of *mix1* to *mix3*'s re-ranking and Yahoo! Japan ranking on "winter solstice"

(a) Re-ranked result by *mix1* on question (a) (Do you want to read this page?).

Rank	Original rank by Yahoo! Japan	Score (improvement from original score of the page ranked by Yahoo! Japan)
1	25	0.73 (+0.35)
2	18	0.23 (– 0.15)
3	23	0.73 (+0.50)

(b) Re-ranked result by *mix2* on question (b) (Do you think this page is visually appealing?).

Rank	Original rank by Yahoo! Japan	Score (improvement from original score of the page ranked by Yahoo! Japan)
1	25	1.00 (+0.82)
2	23	0.73 (+0.35)
3	18	0.73 (+0.50)

(c) Re-ranked result *mix3* on question (c) (Do you think this page is easy to understand?).

Rank	Original rank by Yahoo! Japan	Score (improvement from original score of the page ranked by Yahoo! Japan)
1	25	0.48 (+0.10)
2	23	0.48 (– 0.10)
3	9	0.58 (+0.35)

In summary, our experimental results show that features should be combined based on the characteristics of each query (e.g., a query related to entertainment, a query that children learn in their class, and a query unfamiliar for children) to rank Web pages more children-friendly.

Although we decided the feature combinations of *mix1* to *mix3* based on the dataset obtained from our experiment, we expect these combinations to be effective for general cases when children search Web pages. To rank Web pages satisfying "children want to browse" higher, *mix1* can prioritize Web pages structurally and textually familiar with children. To rank Web pages satisfying "visually appealing to children" higher, *mix2* can prioritize children-oriented Web pages in terms of visual aspects, e.g., image and color. To rank Web pages satisfying "easy to understand for children" higher, *mix3* can prioritize Web pages that contain images and easy-to-understand text for children. Therefore, each of *mix1*, *mix2*, and *mix3* takes into account the characteristics of each aspect of children-friendly pages, and thus, we believe that these combinations are effective for general cases, i.e., searching children-oriented pages. However, to further improve the ranking quality, we should extend our approach so that features can be combined based on the characteristics of queries and children, e.g., age and gender, as our evaluation results show.

5 Conclusion

To support children to use a search engine and find a children-friendly Web page, we proposed a method to re-rank a general search engine's ranking according to the children-friendly score. We thoroughly investigated some conventional field studies on children's acquisition and defined features of a Web page to decide the children-friendly score of the page. Specifically, our method takes into account the structure of the page, amount of images and animations, and its text, to decide the score.

We conducted an experiment to evaluate how a re-ranked result matches with the actual children's perspective to Web pages. As a ground-truth, we asked 34 elementary school students to judge whether a Web page is children-friendly or not. As a result, NDCG of our re-ranked result was 5% to 20% higher than original rankings of commercial search engines. We found that the amount of text, the number of colors, and the number of colloquial expressions for children are the most important features to detect children-friendly pages.

As our future work, we plan to examine an appropriate amount of text and images according to children's age. Additionally, we further examine the best combination of features according to characteristics of queries and children.

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