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POSTERS

Utilizing HTML-analysis and computer vision on a corpus of website screenshots to investigate design developments on the web

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Abstract
We present preliminary results of a project investigating the design development of popular websites between 1996 and 2020 via HTML analysis and basic computer vision methods. We acquired a corpus of website screenshots of the current top 47 popular websites. We crawled a snapshot of every month of these websites via the wayback machine of the Internet Archive platform since the time snapshots are stored to gather 7,953 screenshots and HTML pages. We report upon quantitative analysis results concerning HTML elements, color distributions and visual complexity throughout the years.

KEYWORDS
colors, html, visual complexity, web design, web history, websites

1 | INTRODUCTION

The World Wide Web has become an important part of modern media infrastructure and society. The web itself has also become an object of research in human-computer-interaction (Jørgensen & Myers, 2008) but also cultural and media studies (Brügger, 2012). Investigating the history of web interfaces is an important task for web and media historians but can also give current web designers inspiration on how developments might continue. One important aspect of this research area is the archival of the web and the preservation of this digital heritage has been addressed by the UNESCO.[1] This led to the platform Internet Archive,[2] which, via its Wayback Machine[3] intends to archive the web and enables design researchers to investigate trends on large-scale corpora. We present work-in-progress results of a project investigating web design developments via quantitative and qualitative analysis. We report on our current approach and the first quantitative results we acquired.

2 | METHODS

2.1 | Corpus-acquisition

We decided to analyze the top 50 most popular websites as of December 2019 according to the analytical platform *Alexa*.[4] We filtered out any adult websites, which resulted in a list of 47 websites. We acquired one snapshot per day of these websites stored in the Wayback Machine, if a snapshot was available for the timespan from 1996 to 2020. A snapshot is a stored representation of the website for a given time. This results in a corpus of 151,682 snapshots. However, all websites are represented rather unequally with the most popular and oldest being most

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TABLE 1 Websites of the corpus and number of snapshots

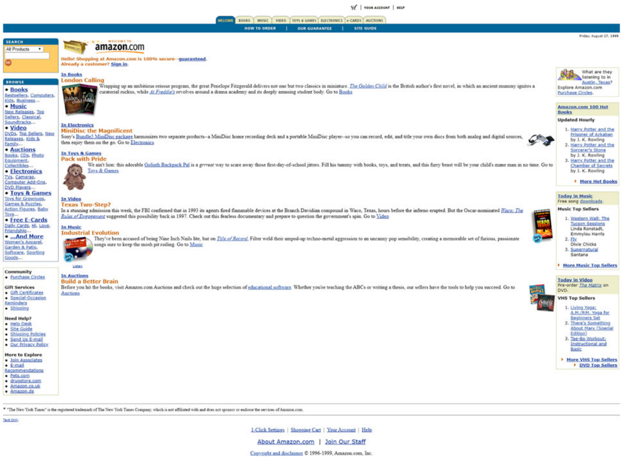
Website	#snapshots	Website	#snapshots	Website	#snapshots	Website	#snapshot
360.cn	152	Facebook.com	200	Office.com	98	Twitter.com	183
Aliexpress.com	121	Google.co.in	194	Okezone.com	155	Vk.com	169
Alipay.com	121	Google.com.hk	199	qq.com	202	Weibo.com	103
Amazon.co.jp	161	Google.com	242	Reddit.com	179	Wikipedia.org	191
Amazon.com	203	Instagram.com	114	Sina.com	218	Wordpress.com	184
Apple.com	242	Jd.com	132	Sohu.com	227	Xinhuanet.com	228
Babytree.com	184	Live.com	102	Stackoverflow.com	138	Yahoo.co.jp	245
Baidu.com	216	Login.tmall.com	92	Taobao.com	126	Yahoo.com	255
Bing.com	159	Microsoftonline.com	124	Tianya.cn	169	Yandex.ru	220
Blogspot.com	107	msn.com	241	Tmall.com	128	Youtube.com	178
Csdn.net	214	Naver.com	229	Tribunnews.com	110		
Ebay.com	240	Netflix.com	153	Twitch.tv	105		

TABLE 2 Website distribution per year

Year	#snapshots	Year	#snapshots
1996	10	2009	378
1997	23	2010	412
1998	26	2011	487
1999	70	2012	494
2000	150	2013	500
2001	183	2014	487
2002	182	2015	491
2003	284	2016	484
2004	317	2017	503
2005	349	2018	498
2006	362	2019	501
2007	394	2020	30
2008	338		

frequent. For this study, we limited this corpus to one snapshot per month per website (the first available snapshot per month) to avoid problems with the unequal distribution. This subcorpus consists of 7,953 snapshots (Tables 1 and 2) of which we scraped the HTML and took a screenshot as TIFF-File with a width of 1920 pixels and height according to the size of website. To enable comparisons, we sliced the screenshots at 3000 pixels height.

The sample size for the early years is rather limited. However, beginning 2003 the sample size is more representative with around 300 snapshots per year. Figures 1 and 2 show two snapshots of amazon.com.



Friday, August 27, 1999

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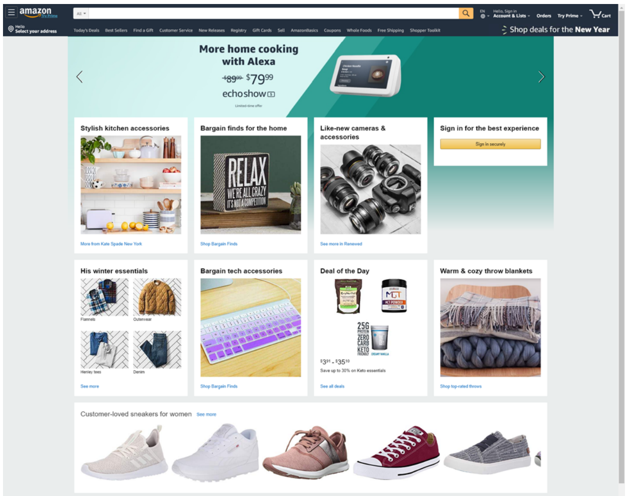
FIGURE 1 Snapshot of Amazon.com (1998)

2.2 | Analysis metrics

We analyzed multiple quantitative metrics: (a) HTML metrics, (b) screenshot size, and (c) color metrics. We counted the number of images via the img-tag, the number of hyperlinks via the a-tag and the overall amount of words in the HTML. Another metric is the size of the screenshots measured in kilobytes after transforming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Sign in securely
His winter essentials
Bargain tech accessories
Deal of the Day
Warm & cozy throw blankets
Customer-loved sneakers for women

FIGURE 2 Snapshot of Amazon.com (2020)

TABLE 3 Overview of the used RGB color ranges

Color	Lower limit (R,G,B)	Upper limit (R,G,B)
Red	(140, 0, 0)	(255, 56, 50)
Green	(0, 170, 0)	(130, 255, 70)
Blue	(0, 0, 145)	(60, 115, 255)
Yellow	(230, 220, 0)	(255, 255, 55)
White	(240, 240, 240)	(255, 255, 255)
Black	(0, 0, 0)	(25, 25, 25)

them to PNG-files. This is an established metric to measure visual complexity and has been shown to correlate with human perception of complexity (Purchase et al., 2012); the larger the more complex an image. We calculated the amount of the base colors red, green, blue, yellow as well as white and black via openCV.[5] Table 3 gives an overview of the RGB-sections we included.

3 | RESULTS

We averaged the number of image-tags, hyperlink-tags and the text per year (see Figures 3–5).

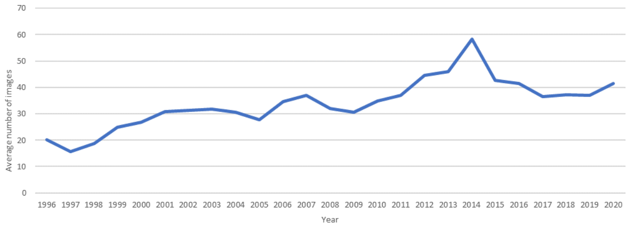

FIGURE 3 Average number of images per year

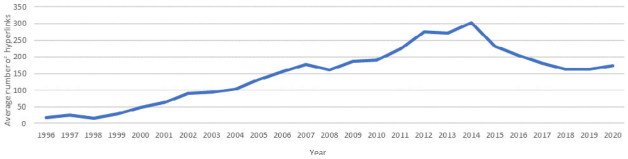

FIGURE 4 Average number of hyperlinks per year

For the number of images and hyperlinks we can identify a steady increase up until 2014 followed by a substantial decrease. A similar development can be found for text up until 2016.

Figure 6 shows the development of the average visual complexity as measured via the filesize.

For this metric, we identified a steady increase until 2020, with the highest leap in the time span from 2009 until 2014.

The color analysis shows that black and white are the most dominant colors since white is the general background color and black the basic font color. Figure 7 illustrates the average proportion of black and white among the websites and shows that most websites consist to around 80% percent of white. However, we observe a small decrease up until now.

While the overall proportion is much lower, we identified red and blue as the most used among the base colors, however without a consistent trend (Figure 8). Beginning with 2013, we can see a more diverse distribution among our analyzed colors. Nevertheless, without a striking trend or development. Please note that the proportions are overall very low, so the significant usage of very popular websites of one color for a year can lead to strong manifestations of this color – which is especially the case for years we do not have many snapshots for (1996–2003).

4 | DISCUSSION

We identified a steady increase of HTML-tags up until 2014 and a remarkable decrease afterwards. A similar but less strong trend is found for the number of words. We hypothesize that these results represent a trend in web design to include more content up until 2014, which is

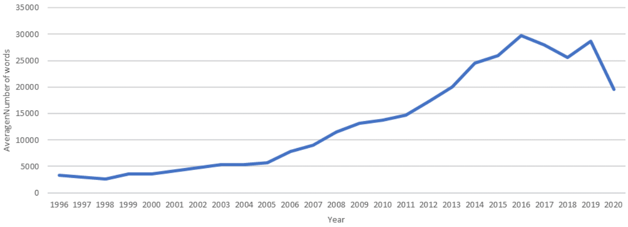

FIGURE 5 Average number of words per year

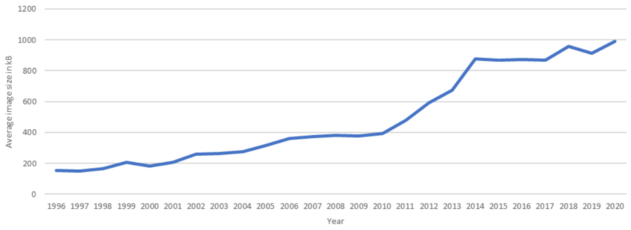

FIGURE 6 Average size of PNG-files per year

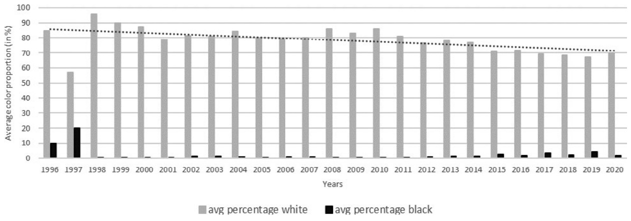

FIGURE 7 The average proportion of black and white among websites

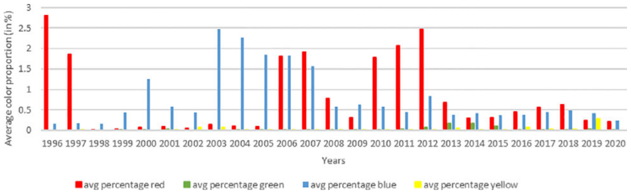

FIGURE 8 The average proportion of red, blue, green and yellow per year

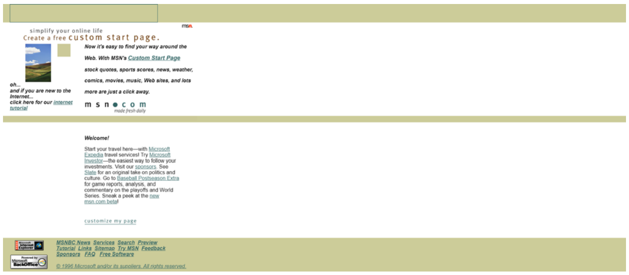

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FIGURE 9 Snapshot of Msn.com (1996)

certainly connected to increased technical possibilities. Snapshots of msn.com in our corpus are representative of this trend (Figures 9 and 10).

After 2014, this trend is followed by a tendency toward more minimalistic designs. This is opposite to the steady increase of visual complexity. The reason for the development of this metric, however, might also be the possibility for designers to include more complex images and graphs with the advent of bandwidth. While the usage of black and white is dominant on websites until now, we identified a higher usage of red and blue in early days and a more

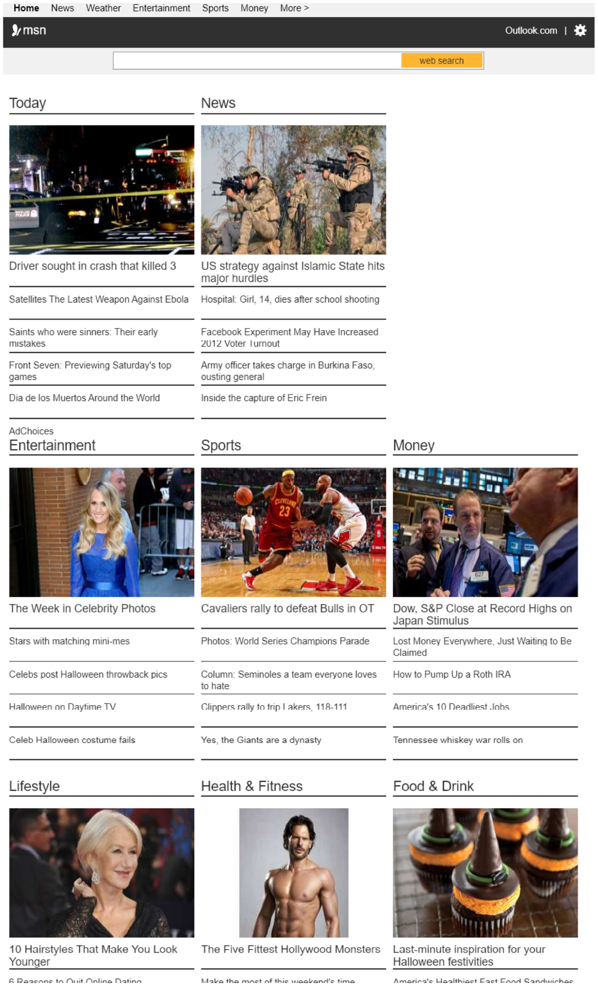

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FIGURE 10 Snapshot of Msn.com (2014)

diverse color usage beginning 2013. Our color analysis is however very limited since we neglect a wide range of other colors.

We want to continue our research by including other quantitative metrics like alternatives for visual complexity and other colors and by analyzing the websites by category. We plan to increase the corpus, especially with websites that were popular in the years 1996–2010 and are not nowadays to get a more representative sample of these times. We pursue a mixed methods approach and want to integrate qualitative analysis of a subset of the corpus to get a better understanding of design developments.

ENDNOTES

[1] https://en.unesco.org/themes/information-preservation/digital-heritage

[2] https://archive.org/

[3] https://archive.org/web/

[4] https://www.alexa.com/

[5] https://opencv.org/

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