

# Using Image Similarity Metrics to Measure Visual Quality in Web Archives

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## CCS CONCEPTS

• **Information systems** → **Digital libraries and archives**; • **Applied computing** → **Digital libraries and archives**; • **General and reference** → *Measurement*.

## KEYWORDS

web archiving, quality assurance, quality, similarity, web archives

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## 1 INTRODUCTION

Web archives are becoming increasingly important to our digital infrastructure, as is judging the quality of these archives. With the growing popularity of complex visual styling enabled by Javascript, AJAX, and cascading style sheets (CSS), visual representation of information on the web has become an important part of judging the quality of archived web pages [8], [5]. In the context of web archives, we define visual correspondence as “the similarity in appearance between the original website and the archived website”, as initially defined by Reyes Ayala (2018) [4]. This paper examines how the visual correspondence of an archived website can be measured using popular image similarity measures. Using these measures we evaluate how visual correspondence can be used as an indication of overall archive quality. We are interested in answering the following research question: How effective are different similarity measures at measuring the visual correspondence between an archived website and its live counterpart?

## 2 METHODOLOGY

### 2.1 The Dataset

We chose three different web archives in order to apply the similarity metrics, two from the University of Alberta and one from the British Library’s UK Web Archives: The “Idle No More” collection [14], the Western Canadian Arts collection [15], and the UK

Web Archives Open Access (OA) collection [9]. “Idle No More” is a topical web archive created by the University of Alberta using the Archive-It service [2]. It aims to preserve websites related to “Idle No More”, a Canadian political movement encompassing environmental concerns and the rights of indigenous communities. The Western Canadian Arts collection, also available on Archive-It, intends to collect and preserve the born digital resources created by filmmakers in Western Canada. The British Library’s OA web archive is a more general collection encompassing UK websites that can be made available online according to British legal deposit laws.

### 2.2 Generating the screenshots

In order to measure the visual correspondence of an archived website to its live counterpart, we created a set of tools called “wa screenshot compare”, currently freely available as a Github repository [3]. Written in Python, these tools take a seedlist as input and generate screenshots of the live websites using Pypeter (a Python port of the Puppeteer screenshot software) and a headless instance of the Chrome browser [12]. “wa screenshot compare” then generates a list of all archived versions of the live sites that are available from the University of Alberta’s Archive-It collection. Screenshots are then taken of the archived websites. For the UK OA collection, we were unable to retrieve every archived capture of the seedlist, we therefore decided to take a screenshot of the oldest capture, since that was usually the capture which web archivists from the British Library analyzed for their QA process.

Despite our initial assumptions, this was not a trivial process. A significant issue was archiving institutions’ use of banners to indicate to users that they are viewing an archived website. Usually these banners include the name of the institution that created the archived website, the name of the collection the site belongs to, and the time and date when the archived website was created. Our initial approach was to append the text “id\_” to the url of the archived websites, as this displays the archived website without the banner, and thus would lead to more accurate screenshots. However, qualitative inspection of the screenshots across all three collections revealed that this approach often breaks the CSS styling of the archived site, resulting in a screenshot that was even farther from the actual appearance of the archived website. A decision was then made to take the screenshots with the banner included, with the assumption that, as the banner is fairly small, it would not impact similarity scores too much.

Link rot was another, more serious challenge to our approach, as many of archived websites are no longer online. As Reyes Ayala (2018) [4] pointed out, visual correspondence can only be measured

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**Table 1: Characteristics of Web Archive Collections Used for Similarity Judgments**

Collection	No. Seeds	No. Seeds Still Available	% Collection Still Available
Idle No More	196	182	92.86
Western Canadian Arts	101	95	94.06
UK Open Access	659	516	78.30

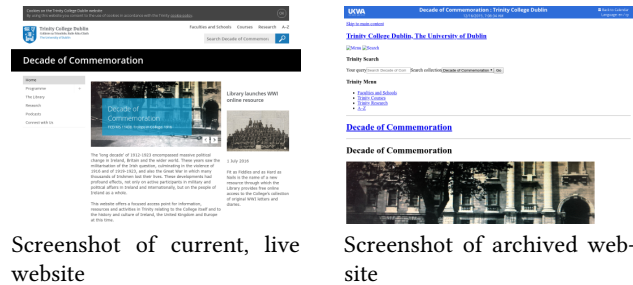
if the original website still exists, otherwise there can be no comparison. Table 1 describes the characteristics of the web archives used to generate screenshots. We categorized as "lost", those websites that returned an HTTP status code other than 200 and were not redirects. From the table, we can see that the UK OA collection has suffered from significant link rot, as almost 22% of the seeds are no longer reachable. The relationship between link rot and web archives has been studied in more detail in [1]. Our experience highlights the importance of conducting visual quality assessments early in the web archiving process, while the websites collected are still online and accessible for comparison.

### 2.3 Calculating similarity

The tool "wa screenshot compare" then puts the two sets of screenshots through a similarity analysis based on two popular image similarity measures: Structural Similarity Index (SSIM) and Mean Squared Error (MSE). We chose SSIM and MSE due to their popularity in the image comparison community and their accessibility. As mentioned above, both SSIM and MSE are easily available in larger Python libraries and there is a large amount of documentation available. MSE is the measurement of difference in pixels between two images without any reference to the vector position of the pixels, meaning that if for example two images contained the same number of measured pixel values the images would be deemed similar, no matter the position of the pixels in the image [7]. The Structural Similarity Index introduces a structural component to the comparison process by taking the pixel vector positions in both images into account, comparing pixel properties across both images one pixel at a time, and preserving the position of the pixels as they are compared [17]. We added a third measure, which we call "vector distance" [16]. Each screenshot is divided into its different pixels. A measure of similarity is then calculated, which produces the distance between the RGB values of each screenshot. The greater the distance, the greater the difference between the two images, and thus, the greater the difference between the two websites. We changed this metric slightly by subtracting every result from 100, thus giving us the percentage similarity between a pair of images. The scales for each measure are shown below.

- SSIM: calculates similarity on a scale of [-1,1]. 1 is perfect similarity
- MSE: calculates similarity on a scale of [0, ∞]. 0 is perfect similarity
- Vector distance: calculates similarity on a scale [0-1]. 1 is perfect similarity

Figures 1 and 2 illustrate how two websites are archived, with very different results. The archived website for Trinity College in Dublin [10], seen in Figure 1, could be classified as one of "medium quality" when compared to the original [6]. The intellectual content



**Figure 1: Comparison of images for the website "Trinity College Dublin: Decade of Commemoration". SSIM = 0.51, MSE = 61536.53, Vector Distance = 59.87**

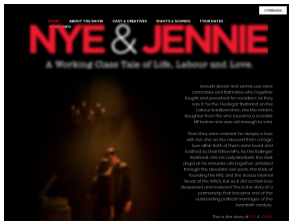
of the website has been preserved, but its styling has been lost, which is reflected in its similarity scores. Interestingly, it yielded a SSIM score of 0.51 and a vector distance score of 59.87. This capture was flagged as having QA issues by web archivists from the British Library. Figure 2 [11] presents an example of an archived website that is of low quality when compared to the original [13]; the archived version is simply a blank page and all content has been lost. This is reflected in the very low SSIM and vector distance scores, and the archived site itself was categorized as a failed capture by web archivists. Throughout our analyses, the MSE measure proved to be the most difficult to interpret, as it has no proper upper bound. It seems MSE works best as a relative measure. We can see the score from the low quality website (169603.88), compare it to the score from the medium quality website (61536.53), and surmise that one capture is worse than the other; however, we will still be lacking an absolute scale.

### 2.4 Correlation Analysis

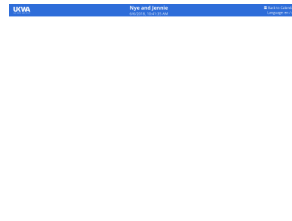
In order to determine if there were relationships between different similarity measures, we performed a correlation analysis on all our similarity scores for the three web archives collections. The results are shown in Table 2. The correlation coefficients indicate that there is a moderate negative correlation between SSIM and MSE score, a very strong negative correlation between MSE and Vector distance, and a moderate-to-strong (depending on the collection) correlation between SSIM and vector distance scores. Since the relationship between MSE and vector distance is an almost perfect negative correlation, this suggests that one measure might be easily substituted for another. Because we found MSE scores relatively difficult to interpret, we recommend the use of vector distance as a measure of similarity.

**Table 2: Correlation between Different Similarity Measures in Web Archives**

Collection	SSIM - MSE	MSE - Vector	SSIM - Vector
Idle No More	-0.61	-0.97	0.61
Western Canadian Arts	-0.72	-0.98	0.78
UK Open Access	-0.63	-0.97	0.69
All	-0.65	-0.97	0.71



Screenshot of current, live website



Screenshot of archived website

**Figure 2: Comparison of images for the website of the play "Nye & Jennie". SSIM = 0.28, MSE = 169603.88, Vector Distance = 8.83**

### 3 CONCLUSIONS AND FUTURE RESEARCH

Our experiments showed that image similarity metrics can be successfully applied in order to measure the visual correspondence (and thus visual quality) of archived websites. Our results indicated that these metrics were able to successfully distinguish between website captures of poor quality and those of higher quality. A natural next step is to conduct experiments to find which similarity measures most closely match up with human judgments of visual correspondence in a web archive. This research is only the first step in developing a comprehensive toolkit for automated or semi-automated quality assurance processes in web archives, which will in turn help web archivists create better web archives.

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