Developing a Tool for the Systematic Recording of Dark Patterns in the Web

Bachelor's Thesis
submitted to the
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Contents

List of Figures

List of Tables

Abstract

Many websites nowadays use malicious design patterns, so-called dark patterns. These are used to trick people into doing things that are not in their best interest. In order to raise awareness and prevent users from falling for those patterns, my thesis introduces an application designed in a way that experts can use it to capture dark patterns and create datasets of them. My application improves existing methods for creating manually labeled datasets of dark patterns. A conducted user study, identified insights and limitations and pointed to areas for improvement. Additionally, a proposed feature to enhance the dataset quality is discussed. This work contributes to the ongoing effort of warning users about deceptive design practices and highlighting the need for further research and innovation in the field of dark pattern detection.

Überblick

Viele Webseiten verwenden heutzutage Designmuster in ihren Nutzeroberflächen, um Nutzer dazu zu bringen, Dinge zu tun, die nicht in ihrem eigentlichen Interesse sind. Solche Muster sind unter dem Namen Dark Patterns bekannt. Um Nutzer davor zu bewahren, auf solche hereinzufallen, beschäftigt sich diese Arbeit mit der Implementierung einer Anwendung, welche von Experten genutzt werden kann, um Dark Patterns auf Webseiten aufzunehmen und Datensätze über sie zu erstellen. Die in dieser Arbeit vorgestellte Anwendung verbessert dabei bestehende Methoden zur manuellen Erstellung von gelabelten Datensätzen von Dark Patterns. Eine durchgeführte Nutzerstudie gab dabei Erkenntnisse über Verbesserungsmöglichkeiten zur aktuellen Implementierung. Darüber hinaus wird in der Arbeit auch eine weitere Funktionalität diskutiert. Diese Arbeit trägt damit zur aktuellen Forschung bei, Nutzer vor täuschenden Designpraktiken zu warnen und zeigt die Notwendigkeit für weitere Forschung und Innovation im Bereich der Dark Pattern-Erkennung auf.

Acknowledgements

I want to express my gratitude to Prof. Jan Borchers for supervising my thesis and Prof. Ulrik Schroeder for being my second examiner.

Special thanks to René Schäfer and René Röpke for advising me on this thesis and offering valuable feedback and guidance throughout the process.

I also want to thank all the participants of the user study.

Lastly, I would like to thank my family for supporting me during my thesis.

Conventions

Throughout this thesis we use the following conventions.

Text conventions

Definitions of technical terms or short excursus are set off in coloured boxes.

> **EXCURSUS:**
> Excursus are detailed discussions of a particular point in a book, usually in an appendix, or digressions in a written text.

Definition:
Excursus

Source code and implementation symbols are written in typewriter-style text.

```
myClass
```

The whole thesis is written in American English.

During the thesis, the presented dark pattern recorder is referred to as the application.

Chapter 1

Introduction

1.1 Motivation

Website operator can design their websites using specific patterns to guide the user through their website. These design patterns have the ability to influence but also manipulate users [Tversky and Kahneman, 1981, 1989, Moser et al., 2019]. Today, many companies are using specific patterns to trick users or customers into doing things that mostly profit the company [Gunawan et al., 2021]. A company can profit from this, by gaining personal information that the user does not want to share. Also, the user might purchase longer subscriptions or more products than the user actually intended to. These patterns are highly effective in doing so and use a well understanding of the human psychology [Xiao and Benbasat, 2011]. An analysis of 680 out of the 10.000 most viewed websites in the United Kingdom came to the result that 88% of those 680 analyzed websites made use of at least one malicious design pattern [Nouwens et al., 2020]. These so-called dark patterns can be defined as the following:

Risk of dark patterns

Definition:
Dark pattern

> **DARK PATTERN:**
> "[...] a type of user interface that appears to have been carefully crafted to trick users into doing things [where these user interfaces] are carefully crafted with a solid understanding of human psychology, and they do not have the user's interests in mind." [Brignull H. and Rosenberg, 2013].

Using such dark patterns has been common practice in the online environment [Kim et al., 2023] [Machuletz and Böhme, 2020]. In addition, increasingly more users are aware of such patterns but still fall for them [Chivukula et al., 2019].

Current approaches and need for labeled datasets

Seeing wide use, potential harm, and many users falling for those dark patterns, some papers tried to create datasets about dark patterns or even build applications that could identify those [Mathur et al., 2019, Soe et al., 2022, Salina and Sangaraju, 2021]. The problem is that current applications that can automatically identify dark patterns in most cases need manually labeled datasets. Approaches using some kind of artificial intelligence need those labeled datasets. The advantage of using artificial intelligence is that it can be very flexible in identifying dark patterns. The problem of these datasets is, that they are time-consuming to create and they often lack in richness of data. Also, very few attempts have been made to recognize dark patterns by using visuals like color differences and specific highlighting.

1.2 Objectives

Goal of the thesis

To address the topic of dark patterns, my thesis tries to solve the problem of easily creating datasets about dark patterns on the web. These datasets feature richer metadata than previous datasets about the dark patterns. Also this thesis tries to speed up the process of creating manually labeled datasets. Thus, the goal of my thesis is a browser extension to systematically create datasets of dark patterns from web pages. The extension is meant to be used by re-

searchers or experts who can capture those dark patterns with a fixed procedure. To achieve this, a combination of screen recording and metadata is used. The metadata consists of browser events as well as user events in the form of hotkeys. After recording the web pages, an editor can be used to further specify and edit the found dark patterns. Moreover, the application will be kept quite flexible in terms of allowing the creation of datasets of different types of web pages. As seen from Habib et al. [2022], Council [2018], Mathur et al. [2019], Gak et al. [2022], Utz et al. [2019], dark patterns engage in many different ways and also on many different websites. These websites can be sites like social media platforms, shopping websites, advertisements or even popups on websites. With this application, it is possible to create rich datasets of dark patterns from all these websites. After implementing this application, there will be a small user study to find out how well users manage to use the application and also find out flaws in the current implementation.

Chapter 2

Related work

Gray et al. [2018] analyzed dark patterns as an ethical phe-
nomenon and revealed the following definition of 11 types
of dark pattern:

Dark pattern types

- Bait and Switch: You set out to do one thing, but a
  different, undesirable thing happens instead.

- Disguised Ad: Adverts that are disguised as other
  kinds of content or navigation, in order to get you to
  click on them.

- Forced Continuity: When your free trial with a ser-
  vice comes to an end and your credit card silently
  starts getting charged without any warning. In some
  cases this is made even worse by making it difficult to
  cancel the membership.

- Friend Spam: The product asks for your email or so-
  cial media permissions under the pretence it will be
  used for a desirable outcome (e.g. finding friends),
  but then spams all your contacts in a message that
  claims to be from you.

- Hidden Costs: You get to the last step of the checkout
  process, only to discover some unexpected charges
  have appeared, e.g. delivery charges, tax, etc.

- Misdirection: The design purposefully focuses your attention on one thing in order to distract your attention from another.

- Price Comparison Prevention: The retailer makes it hard for you to compare the price of an item with another item, so you cannot make an informed decision.

- Privacy Zuckering: You are tricked into publicly sharing more information about yourself than you really intended to. Named after Facebook CEO Mark Zuckerberg.

- Roach Motel: The design makes it very easy for you to get into a certain situation, but then makes it hard for you to get out of it (e.g. a subscription).

- Sneak into Basket: You attempt to purchase something, but somewhere in the purchasing journey the site sneaks an additional item into your basket, often through the use of an opt-out radio button or checkbox on a prior page.

- Trick Questions: You respond to a question, which, when glanced upon quickly appears to ask one thing, but if read carefully, asks another thing entirely.

These types of dark patterns will be used later in the implementation.

Automatic detection of dark patterns has increasingly become of more interest [Mathur et al., 2019, Salina and Sangaraju, 2021, Soe et al., 2022, Gray et al., 2021, Chen et al., 2023]. There have been several first attempts to build a good automatic detection application for dark patterns. Mathur et al. [2019] built an automatic web crawler using OpenWPM, which is a privacy measurement platform. This web crawler is used to simulate a user's browsing experience by opening a shopping website, identifying product pages, adding a product to the shopping cart, and moving on to the checkout page. The classification, which dark patterns were present in the dataset relies on an expert: "Our technique relies on automating the primary interaction path of websites, extracting textual interface elements

present in this path, and finally, grouping and organizing these—using clustering—for an expert analyst to sift through." [Mathur et al., 2019]. For their analysis, the crawler only collected text from websites. From their initial 11k shopping websites, they found 53k product pages featuring a total of 15 different types of dark patterns and 1818 instances of dark patterns. They found those instances on 1254 websites which is about 11.1% of all pages. This percentage seems pretty low since other studies, that only focused on dark pattern occurrences in cookie consent banners concluded that over 50% featured dark patterns [Nouwens et al., 2020, Sanchez-Rola et al., 2019, Utz et al., 2019, Soe et al., 2020]. Additionally, Di Geronimo et al. [2020] analyzed 240 popular mobile apps regarding their dark pattern usage. They found out that 95% of those included at least seven dark patterns in their design. Even tough they were found in mobile apps and not webpages, this just shows how widely dark patterns are used. Mathur et al. [2019] also stated that "In 66 of the 100 pages, our crawler reached the checkout page successfully.". In their future work they stated: "We leave detecting other kinds of dark patterns—those that are enabled using style, color, and other non-textual features—to future work" [Mathur et al., 2019]. This is also where this work might help. With the application presented in this thesis, it is possible to easily create labeled datasets of dark patterns which also feature non-textual metadata. Furthermore, labeled datasets are in most cases needed to train artificial intelligence to complete tasks automatically.

Dark patterns are widely used

Future focus towards non-textual dark patterns

Salina and Sangaraju [2021] chose a different approach to the detection of dark patterns. In their paper, they present an application that is capable of identifying those automatically. The application allows the user to input any URL and then load the page. Next, the application will analyze the source code and alert the user which dark patterns are found and where. The thing that is different about their approach is that they used fixed procedures to identify those dark patterns. Even though this might seem limiting, they claim to have better accuracy than existing apps. Salina and Sangaraju [2021] also did their detection only on text-based patterns since the "[...] in-built web page parser is used to detect such patterns by tags or the keywords [...]" [Salina

Fixed procedure approach to automatic detection

and Sangaraju, 2021].

Both visual and
structural are needed
in datasets

Consensus for
identification needed

Soe et al. [2020] manually collected a dataset of 300 cookie consent banners from several news outlets to see their compliance with the European Union (EU)'s General Data Protection Regulation (GDPR). This dataset includes images and the text of the consent popup. This further shows, that having both a visual component and a structural component in the dataset enables the use of machine learning algorithms: "Our data set allows [...] us to explore using machine learning for dark pattern identification." [Soe et al., 2020]. Another important finding of their work is, that their reviewers struggled to agree on which dark pattern is present in the cookie banner. That plays an important role in using the application as well. The produced dataset is only as good as the person labeling it. Therefore, to produce a good dataset a consensus is needed on which dark pattern types should be looked at and what exactly defines a specific type of dark pattern.

Soe et al. [2022] tried an automated approach to identifying dark patterns in cookie consent banners using their dataset for machine learning. After using different techniques in the machine learning process, they came to the following conclusion: "Lastly, the accuracy of the predictions we obtained is not particularly high." [Soe et al., 2022]. Additionally, they concluded that "A common vocabulary for the identification, description, and categorization of dark patterns (and in concrete contexts) is needed for its comprehensive detection." [Soe et al., 2022]. This further underlines that there needs to be a consensus on what a specific dark pattern defines. But, there are also differences in the types of dark patterns. Some are easier to specify and some are tougher: "During the exercise, it is obvious that Forced action is one of the easiest dark pattern to identify for the reviewers." [Soe et al., 2022]. As a final point, they also reported that it takes a significant amount of manual labeling to get a rich dataset [Soe et al., 2022, Kretschmer et al., 2021, Sanchez-Rola et al., 2019]. This is also the reason why a tool might assist in the creation of labeled datasets with rich metadata.

Another promising approach has been done by Chen et al.

[2023]. They present their tool called UIGuard. UIGuard is capable of automatically recognizing dark patterns in mobile applications only using a screenshot of the interface. They achieved this by combining computer vision and machine learning techniques. An important categorization they made is the distinction between a static and a dynamic dark pattern.

> **STATIC/DYNAMIC DARK PATTERN:**
> Chen et al. [2023] explains a static dark pattern as one that is only specific to one interface and does not need any context or history to be identified as such. A dynamic dark pattern on the other hand, does need further context than the current interface to be identified as a dark pattern.

Definition:
Static/dynamic dark pattern

Chen et al. [2023] used different datasets and models [Deka et al., 2017, Liu et al., 2018, Lin et al., 2015] for training their machine learning. For the dark pattern recognition part, they used a manually labeled dataset: "First, we labeled the types of dark patterns present in each UI. Then, we annotated the positions of these patterns within each UI." [Chen et al., 2023]. Therefore, they used the image annotation tool[1] which assisted them annotating.

Lastly, Nouwens et al. [2020] built a web scraper to scrape the designs of the five most popular consent management platforms (CMPs) on the top 10,000 websites in the UK. This was done to show their compliance with EU's GDPR. Therefore the web scraper collected data using the Hypertext Markup Language (HTML) of the website: "To determine the presence of a particular CMP, the scraper looked for an identifying HTML element within 5–15 seconds of arriving on the site" [Nouwens et al., 2020]. This also shows, that collecting the HTML of a website contains a lot of information about the included dark patterns.

HTML is useful metadata

In summary, there are four main takeaways from the related work for the application presented in this thesis:

Summary of findings

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[1] https://github.com/tzutalin/labelImg, last accessed on 30.01.2024

1. In many cases, a labeled dataset is necessary to achieve automatic recognition of dark patterns [Soe et al., 2022, Chen et al., 2023, Salina and Sangaraju, 2021, Mathur et al., 2019].

2. Metadata in form of both visual like screenshots or videos and structural like HTML or text, makes labeled dataset rich and useful [Nouwens et al., 2020, Salina and Sangaraju, 2021, Soe et al., 2020].

3. Manually labeled datasets are time consuming to create [Soe et al., 2022, Kretschmer et al., 2021, Sanchez-Rola et al., 2019].

4. The quality of a manually labeled dataset can only be as good as the understanding of the person labeling it [Soe et al., 2020, 2022].

Chapter 3

Concept

The issue with current datasets about dark patterns is that they lack rich metadata about the dark patterns. The final output of this application will be a dataset of a website run through that features captured HTML files of the website, a screen recording and events such as tab changes, URL changes and the timestamp for the captured dark patterns. Capturing HTML files gives the advantage of having the website's structure along the recorded video. Besides the named metadata, recording other things like the Cascading Style Sheets (CSS), JavaScript or HTTP Archive files (HAR) was not sensibly realizable which will be explained in more detail in the implementation section. The concept of this application is similar to video annotation tools, where the process is split up into a recording phase and an editing phase. The first reason for splitting up the process is that there are simply too many different dark patterns in order to do everything during the recording using hotkeys. The second reason is that there is no universally applicable definition for dark patterns. And lastly, there might be dark patterns that the user might not notice during recording.

Concept of the application

The first part will be the recording of the target website and during that it is possible to mark timestamps that include dark patterns using hotkeys. There are two types of timestamps that can be made. One hotkey is for capturing a static dark pattern. The other hotkey is marking a dynamic dark pattern. This hotkey will mark an interval of the last 5

Concept of the recorder

seconds.

In the second part there will be an editor to be able to edit the recording which includes the following features:

- Specifying which dark patterns are at the marked timestamps.

- Add overlooked dark patterns during the recording.

- Add new dark pattern types to keep the application flexible and not limit it to the types defined by Gray et al. [2018]

- Minimal export which will only include the most important information in the export.

- Add overlooked dark patterns during the recording. This reduces the file size and moves the focus of the recording to the relevant parts.

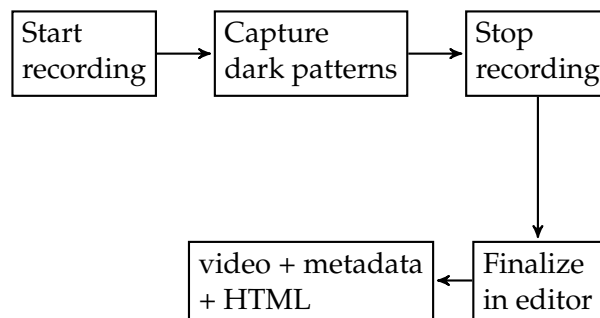Figure 3.1 shows the workflow that the application will have.

Figure 3.1: Workflow of the application

Chapter 4

Implementation

The source code of the application is available at this URL[1].

4.1 Architecture

Before starting the implementation, there was a first major decision to be made: Which type of application is suited best for this application? After some consideration, the best option was a browser extension. This offers full access to the Digital Object Model (DOM) of websites and also all the browser events. Furthermore, it is possible to capture the screen with it. Another advantage of browser extension is, that they are very easy to install.

Deciding on browser extension

The second decision to be made was, which frameworks should be used for the implementation. The first framework is called Plasmo[2]. Plasmo makes it very easy to setup a browser extension project and develop it using a hot reload development server. Plasmo also makes the build process for different browser types like Google Chrome and Mozilla Firefox very easy. The second framework used in

Used frameworks

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[1]`https://git.rwth-aachen.de/i10/thesis/`
`thesis-florian-pluemaekers-dark-pattern-data-set`
[2]`https://github.com/PlasmoHQ/plasmo`, last accessed on 30.01.2024

the implementation is React[3]. React is a frontend framework which makes it easier to structure your application and most importantly update the user interface (UI) when data or variables are changing. The decision for this specific frontend framework is mostly personal preference but also because it is the most popular frontend framework and there is a large community using it. The last framework used in this project is Material UI[4]. This is a component library that supports the design of the app. It makes it much more effortless to get the application to have a consistent theming due to many preconfigured components that can be used.

4.2   Recorder

Screen recording

After those decisions have been made, the first big thing to implement was the screen recording. The only way to do this is using the integrated browser application programming interface (API). This has the downside, that the user has to manually select which screen/tab/window should be recorded (see Figure 4.1). The recommended option in this dialog is "Entire Screen" since popups or changes in the title of the browser tab might get lost when not doing so. Using the browser API also has another limitation: Calling the recording function is only possible inside a webpage and not in the extension itself. This is the reason why the recorder is also prominent in the web application where the editor is implemented. Additionally, for the recording to work, the user has to open the recorder and leave it open during recording. Otherwise, the recording is terminated.

Data collection

Next, it was important to look what data can be collected for the recording using a browser extension. As previously mentioned, the screen can simply be recorded using the browser API. The HTML is easily obtainable using the JavaScript function `document.querySelector("*")`. To mark a specific timestamps, hotkey presses can simply be listened to using key listeners.

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[3] `https://react.dev/`, last accessed on 30.01.2024
[4] `https://mui.com/`, last accessed on 30.01.2024

Choose what to share with Dark pattern recorder

The site will be able to see the contents of your screen

| **Chrome Tab** | Window | Entire Screen |

G Google

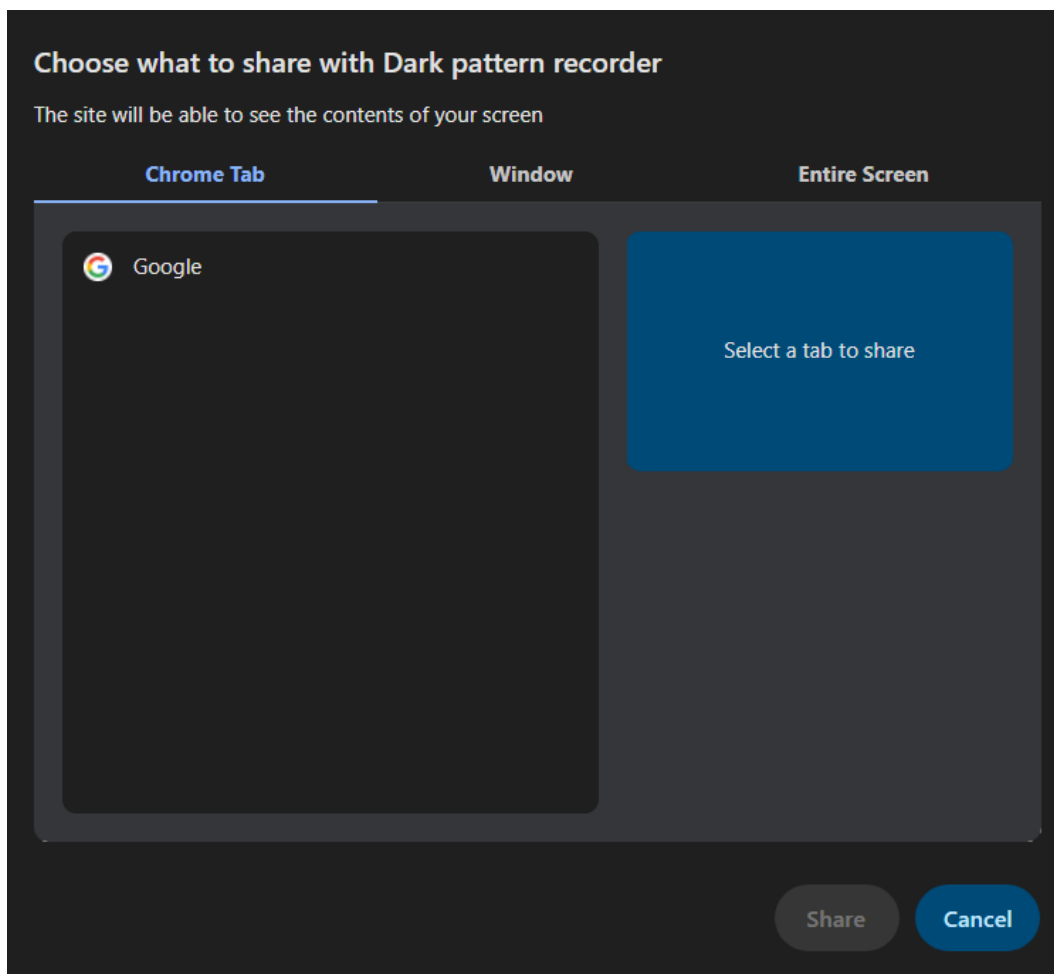Select a tab to share

Share Cancel

Figure 4.1: Screenshot of the Chrome display select dialog

During developing, another type of data also came into consideration. At first, recording all the network traffic seems like a great idea, since it should be possible to recreate every website using HTML, CSS and images in the recording. But actually, it is not that simple. Websites like Youtube.com[5] are pretty much sending an empty HTML file where everything is loaded afterwards using JavaScript. This makes it impossible to recreate every website. Additionally, the implementation of this would also have more restrictions. To access the network traffic, it is necessary to also extend the devtools of the browser. As a result, to be able to have access to the network traffic, it

Trying to record all network traffic

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[5]`https://www.youtube.com/`, last accessed on 30.01.2024

would be necessary to open the devtools during the recording. After doing so, this would also only apply to the tab, where the devtools are opened for. Therefore information of newly opened tabs or popups would get lost.

Attempt to record all styles

Another approach was to only record the HTML and CSS. This could be achieved by calling the JavaScript function `getComputedStyle` on every HTML element. Doing so, significantly slowed down the browsing experience. As a result, this was also not an option.

Final implementation of HTML recording

In the final implementation, the recorder saves the HTML every second of the currently focused tab and also when a hotkey is pressed. In a previous version, I attempted to capture the HTML whenever changes occurred within the HTML. When opening e.g. Youtube.com[6] this lead to so many change events that the extension immediately crashed. To reduce unnecessary large recordings, the hash values of the current and previous HTML file are calculated and if they are the same, the new HTML will not be saved.

Recording file format

The file format of a recording is a Zip file. This is due to the many different files like the WebM video file, many HTML files and the metadata JavaScript Object Notation (JSON) file. This offers many advantages. At first and most obviously, it is not necessary to save a large amount of files. Secondly, the Zip file compresses the files, thus reducing the file size. The folder structure of the Zip file can be seen in Figure 4.2:

```
<Recording Subject>.zip
  html
      <timestamp>.html
      <timestamp>.html
  video.webm
  metadata.json
```

Figure 4.2: Folder structure of the recording

Decision against SRT file format

For the metadata file, I have chosen the JSON format because it is very flexible, easily human readable and widely

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[6]`https://www.youtube.com/,` last accessed on 30.01.2024

used. Thinking about other options, a SRT file type also came into consideration. SRT files are used for subtitles of videos. The format itself is pretty easy, Listing 4.1 shows an example of a SRT file:

```
1
00:00:01,459 --> 00:00:03,522
This is the first subtitle
2
00:00:5,851 --> 00:00:11,984
This is the second subtitle
```

Listing 4.1: .srt file structure

This format actually fits pretty well, but it does not offer a data structure for the contents of the subtitles like "This is the first subtitle". Therefore, the JSON file format is the better choice. Listing 4.2 shows the schema of the meta-dataJSON file:

Decision for JSON file format

JSON data structure

```
{
    subject: String
    keyframes: Keyframe[]
}

Keyframe: {
    time: Number,
    endTime?: Number
    tabId: Number
    windowId: Number
    type: String
    url: String
}
```

Listing 4.2: Schema of the metadata.json file

With the `subject`, being the title of the recording and an array of `keyframes`. The `keyframes` refer to browser events or captured dark patterns. The time of a keyframe is the timestamp in milliseconds after the recording has started. The `endTime` is optional and is only present at dynamic dark patterns which then marks the end of the time span. The `windowId` and `tabId` are the ids from the

browser that can be used to differentiate between different tabs, windows or popups. The type property has the following values:

- `FOCUS_CHANGED`: The user changed the tab or window

- `URL_CHANGED`: The URL of the current tab changed by the user or by navigation

- `TAB_CHANGE_TO_RECORDER`: When the user focuses on the recorder

- `TAB_CHANGE_FROM_RECORDER`: When the user switches away from the recorder

- `<Dark pattern>`: The value of this depends on the dark pattern that is annotated here. This can either be a predefined dark pattern or a custom dark pattern that the user has specified in the editor.

Frame count as
timestamp is not
possible

Lastly, the `url` property is simply the URL of the currently focused tab at the given time. All the timestamps used in the application are in milliseconds after the recording. The other option that I would have liked to use would be the exact frame count. Unfortunately, this is not possible, because the way the screen is recorded, it is not using a constant frame rate and that is why it is not possible to get the timestamp in a frame count format. In order to provide guidance mainly during the recording phase, there is a step by step kind of timeline. This shows dynamically at which step of the recording the user is and what the user needs to do to proceed (see Figure 4.3).

4.3   Editor

The editor mainly consists of 3 parts, the video, the timeline and the dark pattern overview menu (see Figure 4.4).

Video controls

The video is used to see the replay of the recording. The controls underneath the video can be used to navigate
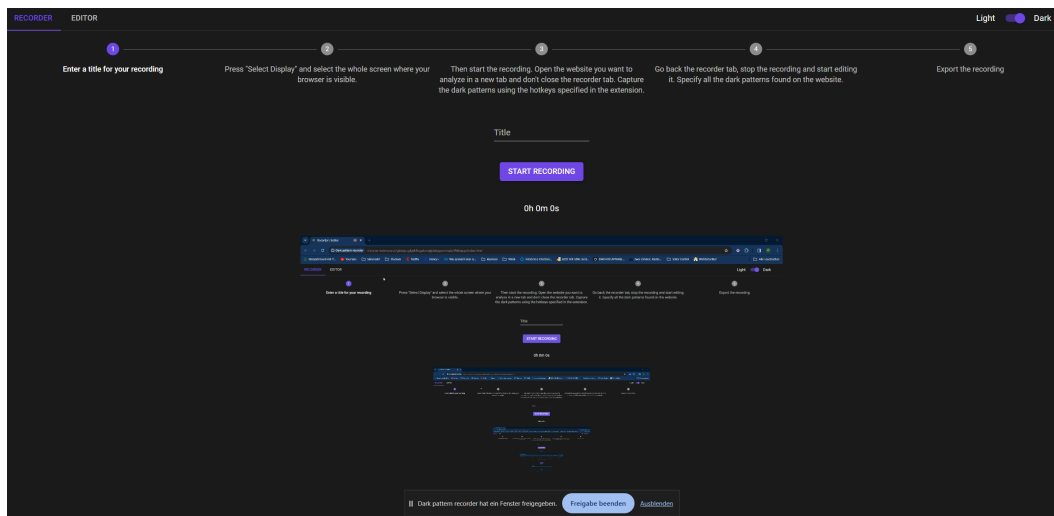
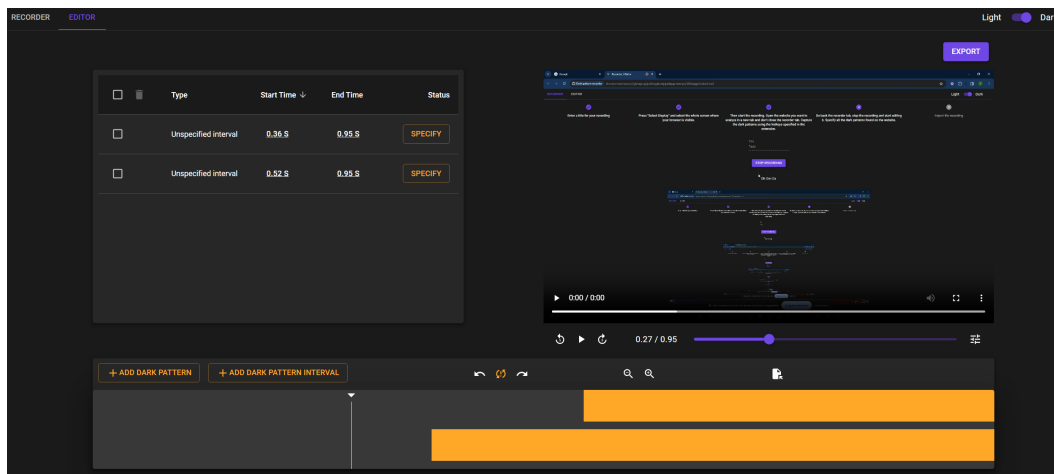**Figure 4.3:** Screenshot of the recorder when a display is selected

Figure 4.4: Screenshot of the editor

throughout the recording (see Figure 4.5). Those controls include a pause and play button and the corresponding hotkey space-bar for easier usage. Furthermore, there are buttons to skip 5 seconds forwards or backwards which can also be achieved using the left and right arrow keys. Additionally, the mini timeline provides a good overview where you are in the video. Since the video is not taking up the whole screen, sometimes the video might be too small. Therefore, the editor has a button to enable or disable the video controls. The video controls are the default ones pro-
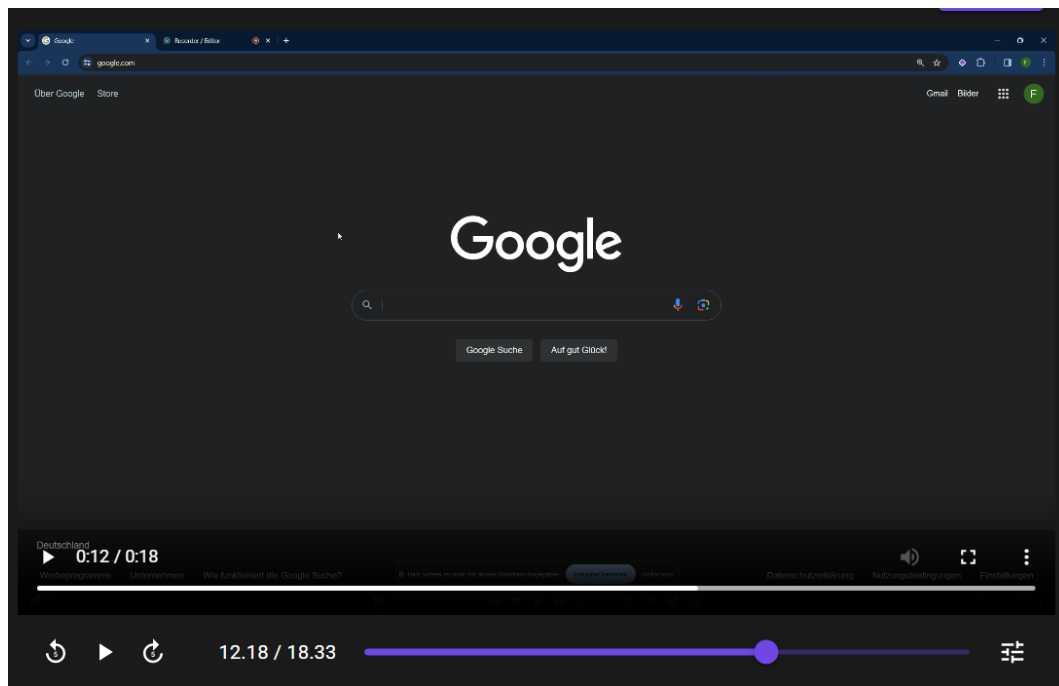
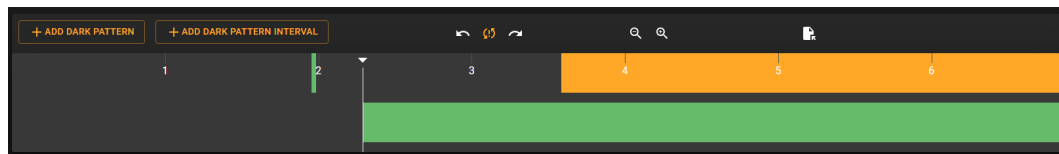**Figure 4.5:** Screenshot of the preview video in the editor

Figure 4.6: Screenshot of the timeline in the editor

vided by the browser. With the video controls enabled, it is possible to view the video in full screen to see more clearly.

Timeline controls   The main timeline can be used to add dark patterns or select them (see Figure 4.6). You can either add a static or a dynamic dark pattern. When clicking at a dark pattern in the timeline, it will be selected. If there are dark patterns in the timeline, two buttons can be used to navigate to the next and previous dark pattern. Alternatively, the hotkeys A and D can also be used to do so. Additionally, there is a button (or pressing the tab key) for cycling through all the unspecified dark patterns. This feature is added because in larger recordings with many marked dark patterns, it makes it easier to find those unspecified ones. This button

Figure 4.7: Screenshot of the dark pattern menu in the editor

is highlighted when there are unspecified dark patterns. To navigate more easily through the recording, there are two buttons (or pressing + and - keys) to zoom inside the timeline. When zooming in the timeline, the mouse wheel or the slider at the bottom of the timeline can be used to navigate through the timeline. Lastly, the timeline has the function to download the HTML of the current timestamp. This will simply take the previous HTML from the currently visible page. In some cases there might not exist a HTML file at the current timestamp, this is just a limitation of only saving the HTML file in intervals. If this is the case an error message will be displayed.

The dark pattern menu (see Figure 4.7) is a table that shows every dark pattern marked in the recording. This table can easily be sorted by the type of dark pattern, the start time, the end time or whether the dark pattern is specified or not. The table also offers the option to select and then delete

Dark pattern menu
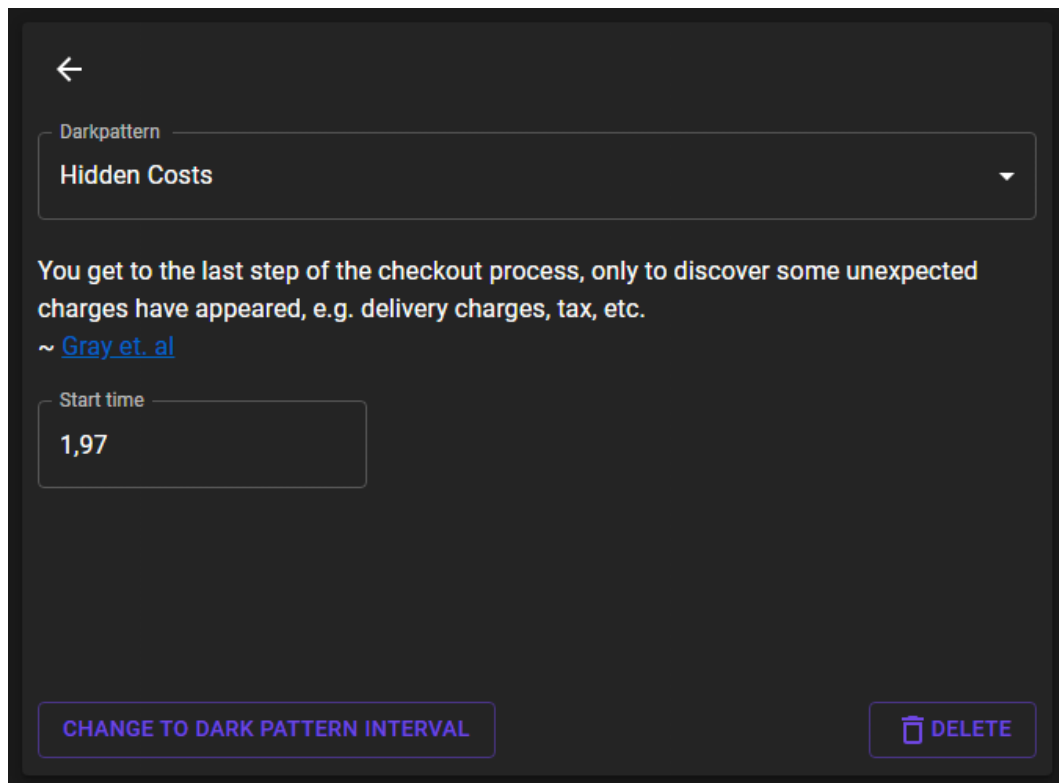
Figure 4.8: Screenshot of specifying a dark pattern in the editor

multiple dark patterns at once.

Specifying a dark
pattern

When a dark pattern is selected by clicking (see Figure 4.8), the dark pattern can be further specified by giving it a specific type and the time it appears in the video can be edited. Additionally, it is possible to change whether it is a dynamic dark pattern or not. It also shows the explanation for the predefined dark pattern types of Gray et al. [2018]. The drop-down menu for selecting which type of dark pattern is present in the video, also offers the ability to add types of dark patterns that are not covered by the predefined types.

Export menu

Lastly, when the user has finished editing and specifying dark patterns in the recording, the user can export the recording. The user can choose which files should be included in the recording (see Figure 4.9). Additionally, there is an option "Minimal Export" that will only include those HTML files that correspond to a marked dark pat-

Export

Choose what the export should contain...
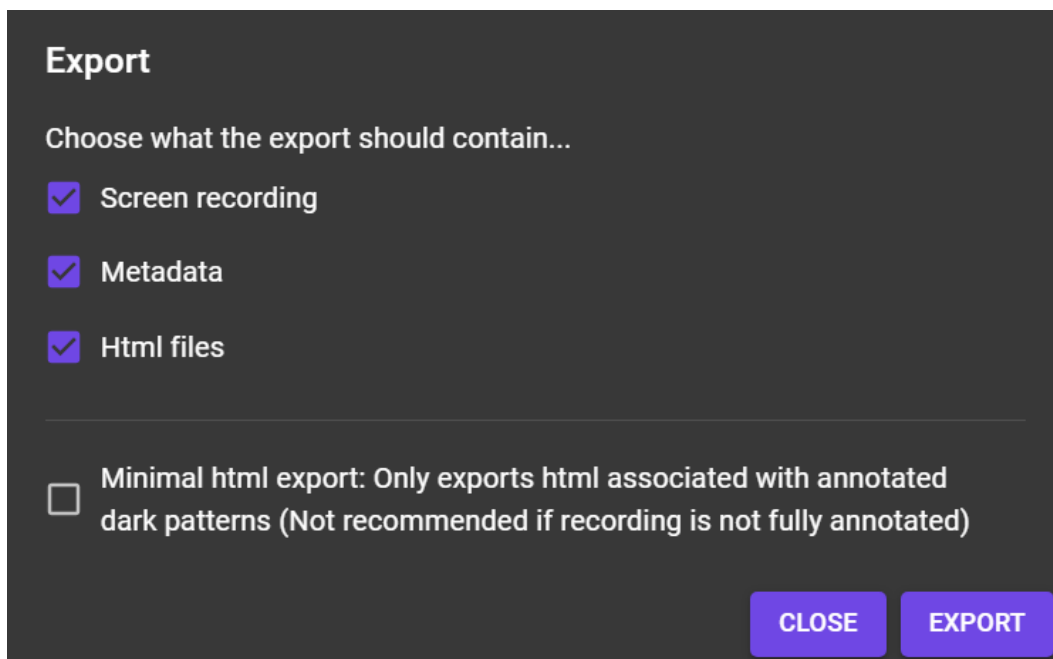
☑ Screen recording

☑ Metadata

☑ Html files

☐ Minimal html export: Only exports html associated with annotated dark patterns (Not recommended if recording is not fully annotated)

CLOSE   EXPORT

Figure 4.9: Screenshot of the export menu in the editor

tern. This includes the same HTML files like when pressing the download HTML button on every marked dark pattern. For static dark patterns it will simply include the closest previous HTML file to the time of the dark pattern. For dynamic dark patterns it will also include the closest previous and also every HTML file within the specified interval.

For the design of the Editor, I have chosen to stick to four design principles: Proximity, Alignment, Repetition and Contrast. Proximity means that similar functions and information should be close to each other. In the editor, this is implemented using the described three main sections. The Alignment helps the user to be able to read the interface faster. This is achieved through having both vertical and horizontal orientation lines. The repetition design principle refers to the use of similar styled elements through out the interface. The repetition is achieved mostly through the use of the framework Material UI[7]. It offers predefined components that have a repeating design. Lastly, the contrast design principle assists the user in dragging his attention

Design principles

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[7]`https://mui.com/`, last accessed on 30.01.2024

to certain important parts of the interface. Warmer colors like yellow and red are more eye-catching than cooler colors like blue and purple. The editor is using this principle in a way, that it drags the attention of the user to the most important parts like adding dark patterns and specifying dark patterns. The color to do so is an orange which is very eye catching. For less important controls white or purple (a cooler color) is used.

Chapter 5

Evaluation

5.1 Methodology

To evaluate the application, I conducted a user study. The goal of this study is to analyze the usability of the interface. Therefore, it is necessary to find out what works good in the application's workflow and which parts are not flawless and might need to be reworked. The user study included a total of 6 participants. All of the participants were familiar to the topic of dark patterns. This is done because the application is designed to be used by experts on the topic of dark patterns. The setup used for the user study is a laptop, running a Google Chrome browser with the application installed. An important part to get comparable results is to always use Google Chrome with no user signed in and all cookies, history etc. of the browser needed to be deleted. The procedure of the study was always the following:

Setup of the user study

Procedure of the user study

1. The goal of the study was communicated to the participant, which is to find out how well users utilize the application and not to test their understanding of dark patterns.

2. The users had to sign a consent form, that they are fine with using their data in anonymized form. The consent form included the following parts: Purpose,

procedure, risks, confidentiality, costs and compensations

3. The participant is asked to fill out the questionnaire part one. This part includes 3 questions about the participant: The age, latest degree acquired and a self-assessment of their knowledge of dark patterns on a 5-point scale.

4. The participant gets an explanation of the application. This includes an explanation of the application and also the list of dark patterns from Gray et al. [2018] that the application offers by default. This explanation is for all users the same, since giving users different information about the application might influence how they deal with the application later.

5. The participant is asked to edit one of the two tasks. Both tasks ask the user to speak out their thoughts during the completion of the tasks. One half of the participants gets the task a) as the first task and the other half gets task b) as the first task. This is done because the Apple.de task does not have that many obvious dark patterns like the Booking.com task.

   a) Apple.de task: This task includes creating an annotated recording using the application of Apple.de[1]. Therefore, they should configure an iPhone 15 and add it to the cart using the buy directly option.

   b) Booking.com task: This task includes creating an annotated recording using the application of Booking.com[2]. Therefore, they should look for an accommodation as soon as possible in Hamburg for 2 persons and 1 night. They should follow this process until they are asked in the checkout for personal information.

6. The participant is asked to complete the other task. The study features two independent tasks because this way it can be analyzed how well the participant learns to use the application.

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[1] https://www.apple.de, last accessed on 30.01.2024
[2] https://www.booking.com, last accessed on 30.01.2024

7. The user is asked to fill out the second part of the questionnaire. This includes a Questionnaire for User Interface Satisfaction (QUIS) [Chin et al., 1988]. I have chosen this questionnaire, because it features interface specific questions. Furthermore, seeing the different questions asked there, if the results for one question are pretty low, it is pretty easy to identify the problem that should be fixed. Additionally to the QUIS, the user is asked to freely write what they liked/disliked, suggestions for improvement and other comments. The questionnaire is split up into two parts, because the first one also asks for the self-assessment of their knowledge on dark patterns. Finishing the tasks first might affect their self-assessment regarding dark patterns.

5.2 Results

From the first part of the questionnaire emerges that the participants were in the range of 19-30 years old with an average age of 23.5 years old. Four of the participants latest degree was a high school diploma. The rest of the participants latest degree was a bachelor. Furthermore, four of the participants rated their self-assessed dark pattern knowledge at 4 out of 5 on the scale, while two participants indicated a 5 out of 5 rating. On this scale a 1 would indicate no prior knowledge and 5 indicating very much prior knowledge. Next, the results of the second part of the questionnaire can be seen in table 5.2. The results of the QUIS are presented by the mean values of each question asked. Table 5.1 shows all the feedback the participants gave. This includes both positive and negative feedback. Also, the quantities of the given feedback is displayed in the "Count" column.

Results of the questionnaire's first part

Feedback	Count
No feedback for hotkey	6
Chrome display select dialog unclear	4
Wish for easier adjustment of timestamps	4
More explanation needed	3
Adding dark patterns intuitive	3
Color scheme good	3
Specifying multiple dark patterns in the same screen was unintuitive	3
Unclear when recording starts	3
Timeline to skip through video was useful	2
Adding more dark pattern types was helpful	2
Explanation of dark patterns too late	2
Wish to specify where exactly a dark pattern is in the screen	2
Explanations useful	2
Full-screen: No hotkeys, no overview of dark patterns	2
Starting second recording was confusing	2
ALT as hotkey caused confusion	2
Was Missing to use hotkeys in editor	2
Dark pattern menu gave good overview	1
Unclear, what exactly is saved by pressing hotkey	1
Confusion after closing export menu during export	1
Dark patterns easy to delete	1
Hotkeys during recording were easy to use	1
Functions were first unclear	1
Explanation of minimal export unclear	1
Build-in editor in principle good	1
Scrubbing in video not smooth	1
Delete button in bottom right intuitive for OK/Save-Button	1
Cycling through dark patterns was good	1
Decision-tree for dark patterns specification	1
Cycle through dark patterns icon was confusing	1
Not able to select multiple dark patterns in timeline for deletion	1
In editor interval gets added for the future 5 secs instead of past	1
Button color for "Change to dark pattern" and "Delete" bad contrast	1
Inconsistent terminology export / download recording	1
Warning in export was useful	1
Title of recording not changeable in editor	1
Change to Interval unintuitive	1
Zoom Buttons unclear	1
Recorder preview unclear	1
Confused by red dot always visible in chrome tab	1

Table 5.1: Results from the study: Participant's feedback and number of partici-
pants who expressed it. Feedback is in form of notes from participants or spoken
thoughts.

Question	Mean rating
Overall Reactions to the System	
terrible/wonderful	7
difficult/easy	6.17
frustrating/satisfying	6.33
inadequate/adequate power	7.83
dull/stimulating	6.5
rigid/flexible	7.17
Screen	
Characters on the computer screen	6.33
Highlighting ...simplifies task	6.83
Organization of... screen	6.67
Sequence of screens	7.33
Terminology and System Information	
Use of terms throughout system	8.33
Computer terminology is related to the task you are doing	8
Position of messages on screen	7.33
Messages prompting ...input	7.17
Computer keeps you informed...	6
Error messages	6.33
Learning	
Learning to operate the system	6.67
Exploring ...by trial and error	7.5
Remembering names and commands	8.17
Tasks can be performed in a straight-forward manner	7.67
Supplemental reference materials	7.5
System Capabilities	
System speed	8.67
System reliability	7.67
System tends to be noisy/quite	7.33
Correcting your mistakes	7.67
Experienced & inexperienced users' needs are taken into consideration	7

Table 5.2: Mean ratings of the study's QUIS

Chapter 6

Discussion and limitations

6.1 Interpretation

The study gave some interesting insights how the application performed. First, I noticed the lowest rating for "Computer keeps you informed" (see Table 5.1). This can be explained by multiple answers shown in table 5.1. First, every participant was confused by not having a feedback when pressing a hotkey during the recording. Second, three out of six participants were not sure when the recording actually started. Further, this can be confirmed by one participant being confused that the red dot is always visible in the browser tab (see Figure 6.1). The reason for this is that the red dot does not represent whether it is recording or not. Also, one participant closed the export menu during export and a couple of seconds later the editor closed after the exported recording was downloaded.

Application did not inform participants well what's happening

Another outstanding rating is the "Learning to operate the system" with a mean rating of 6.67. Also the experience expressed by multiple participants might have contributed to this rating: "More explanation needed" expressed by three participants, "Not able to select multiple dark patterns in timeline for deletion" expressed by one, "Specifying mul-

Application not that intuitive to learn

tiple dark patterns in the same screen was unintuitive" expressed by three, "Delete button in bottom right intuitive for OK/Save-Button" expressed by one, "Was Missing to use hotkeys in editor" expressed by two.

Imperfections with the video in editor

Furthermore, the rating for "Characters on the computer screen" of 6.33 stood out to me. This may be due to the small screen of the laptop used in the setup. Further, everyone used the full-screen mode to look for dark patterns in the recording. Thus, drawing the attention to critiques like "Full-screen: No hotkeys, no overview of dark patterns" which definitely has some room for improvement. Also "Scrubbing in video not smooth" could be a reason to this rating. This means that using the timeline, with the video paused, to navigate through the video was not completely smooth and responsive.

Positive feedback

Since the study was conducted to find out imperfections about the application, the focus was on negative feedback and what could be done better. Nevertheless, also positive aspects were mentioned. "Remembering names and commands" stood out with a rating of 8.17. This observation possibly indicates that the usage of hotkeys, both in the recording and editing phases, was perceived as pretty intuitive. Additionally, this perception is noted by the feedback of half of the participants: "Adding dark patterns intuitive" and one participant saying "Hotkeys during recording were easy to use". Also, half of the participants found the color scheme as quite helpful. Mainly the usage of the color orange, the highlighting color, drew the participant's attention to the important parts of the application.

Summary of results

To sum up the results of the user study, the results have shown promising results, although there is still some room for improvement to further enhance the user experience of the application. The biggest enhancement the application is lacking currently, is the feature to exactly specify the location of a dark pattern using something like boxes to draw around the area. Even though this was only mentioned by two participants, seeing also Chen et al. [2023], clearly shows that this would be helpful. This would further enrich the dataset and make it even more useful. Additionally, reworking the explanations would also prevent a lot of

confusion regarding the browser display select dialog (see Figure 4.1).

Comparing this approach to manually annotating images like in Chen et al. [2023], the dataset provided is richer and is at least as fast to create as using other approaches. Furthermore, using a manual approach eliminates the error that might happen when using a web-crawler since it is possible that a web-crawler is not able to recognize certain website paths [Mathur et al., 2019]. Additionally, using the HTML as a source for the text inside the web page, eliminates the error of wrongly detecting characters using computer vision [Chen et al., 2023]. Looking back at the goal, this application can be seen as a first implementation of a tool that allows an easier and faster creation of dark pattern datasets of webpages.

Comparison to other work

Another learning from this work is that having a clear definition of what a type of dark pattern actually defines is very much needed. Besides Soe et al. [2022], also the presented user study showed that participants struggled to decide on which dark patterns are present in the recording. In the application, I don't provide further assistance besides the explanation of Gray et al. [2018] because I want to keep the application open for usage with other types of dark patterns than Gray et al. [2018].

Clear definition of dark patterns is very important

6.2 Possible improvements

Since the user study highlighted imperfections in the application, here are some possible improvements that can be made to improve the workflow.

First of all, many participants did not cope well with the explanation in the recorder tab. This might be due to the amount of text or maybe even unclear instructions. Possible solutions to this might be using a demonstration video or screenshots to explain the workflow in detail. Choosing a more vivid approach might be the better solution to catch the user's attention more.

More vivid explanations

Better feedback solutions

Next, every participant complained about the missing feedback for pressing the hotkeys during the recording. This caused confusion whether the press was registered to or not. Therefore, an auditory feedback would be best, since it informs the user without obstructing the view or potentially covering dark patterns in the recording.

Improvements to dark pattern menu

Participants also were not sure if the added dark pattern got saved when they pressed the arrow button in the top left (see Figure 4.8). I would suggest to move the "Delete" button and put a save button there. Additionally, changing the color of the "Delete" and "Change to dark pattern interval" button would increase their visibility.

Drawing boxes around dark patterns

Another thing that participants were missing, was the ability to specify where exactly the dark pattern is in the interface. This definitely makes sense since Chen et al. [2023] also used an image annotation tool[1] to specify where exactly the dark patterns are in the image. Implementing a solution similar to the image annotation tool would be great, where it is possible to drag boxes around the dark patterns.

Custom full-screen mode

Furthermore, one participant mentioned that hotkeys were not working in full-screen mode and also that there is no information about all the dark patterns. This is also pretty important, besides only one person mentioning it, every participant used the full-screen mode. The problem here is that the full-screen is implemented using the browser's default video controls, which seems to suppress all key press events. This could be solved by implementing a custom full-screen mode. This custom full-screen could increase the video height to just leave enough space for the timeline including the controls (see Figure 4.6). This way the hotkeys would all work fine with also having the information of all the dark patterns in the recording.

Prevent closing export menu

Being able to close the export menu during the export, was also confusing to one participant. Not allowing to close the export menu during export, would solve this problem.

Screen share indication should represent recording state

Participants were also confused because the red dot at the

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[1] `https://github.com/tzutalin/labelImg`, last accessed on 30.01.2024

Figure 6.1: Screenshot of the Chrome tab after selecting a display (see Figure 4.1)

browser tab (see Figure 6.1). This dot does not represent whether it is recording or not. Therefore, immediately starting the recording after the display selection (see Figure 4.1) and cancelling the screen sharing when pressing the "Stop Recording" button would solve this problem.

Next, during the study, the default hotkeys ALT+A and ALT+S did not seem to be a good choice. On Apple.de[2] this drew boxes around certain HTML objects which caused confusion whether this was intended or not. ALT in general, seems to be a bad hotkey. Using different default hotkeys would be better.

Other hotkeys

Also adjusting the timestamps of dark patterns felt tiring to the participants. A solution described by one participant is to be able to adjust the position in the timeline. Also adjusting the length of intervals would be helpful. Another participant mentioned the ability to add dynamic dark patterns using a button to set the start position of the interval and a button to set the stop position of the interval. This would also be a great solution to make the adjusting easier.

Solutions for easier adjustment

Another aspect that would make the application more intuitive, would be allowing the user to use the hotkeys for adding dark patterns also in the editor.

Dark pattern hotkeys also in editor

Furthermore, a participant described that adding a box around the preview video in the recorder would help elevate the preview from the background and can also be used to indicate whether the recorder is actually capturing or not.

Border around video preview in recorder

Next, a participant mentioned, being able to select multiple dark patterns in the timeline (see Figure 4.6) in order

Select multiple dark patterns in the timeline

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[2]`https://www.apple.de`, last accessed on 30.01.2024

to delete multiple at once would be helpful. This could be achieved by using CTRL or ALT to be able to select multiple dark patterns in the timeline at once.

Fix for dynamic dark
patterns

Also, adding an interval in the editor seemed confusing, since it does not cover the last 5 seconds, instead it covers the future 5 seconds. The fix for this should synchronize how the interval gets added by the hotkey and how it is added in the editor.

Discard recording

Lastly, an option to discard a recording after stopping a recording would help, when something unplanned happened.

6.3   Technical constraints

Recording HTML in
intervals

The application had to deal with several technical constraints. First of all, there is the interval of 1 second between recording the HTMLs. On the one hand, this makes the recording imprecise since the user interface might change in this one second and the saved HTML would not be accurate anymore. On the other hand, saving the HTML in intervals, opens up the possibility of having certain timestamp where no HTML exists.

Complete
reconstruction not
possible

Following this, since only the HTML of the website is saved, a complete visual reconstruction is not possible. Even if it would be possible to easily access every resource of a website, this would dramatically increase the size of a recording. To achieve this, it is also necessary to save every slightest change in the HTML of the website to not miss any changes.

Recording length
limited

The third limitation is the possible maximum duration of a recording. Since all the information gathered in a recording is saved in a variable, recording for too long will result in an overflow error where the recording will get lost.

Display select dialog
was confusing

Another limitation emerged during the user study. Many participants struggled at first with the browser's display select dialog (see Figure 4.1). The browser does not allow the

option of only opening the dialog with the "Entire Screen" option.

 Another result from the user study further showed, that using the same set of dark pattern types and also most importantly the same definition of dark patterns is absolutely mandatory to produce as usable datasets. The results of the found dark patterns in the recordings were vastly different. One participant mentioned that adding a decision tree for the types of dark patterns would be helpful. This can definitely be the case but should instead be done by the experts using the application. Implementing it in the application does not make that much sense since this would restrict the user to a certain set of types.

Very different recordings created in study

 Lastly, the indication of time is only possible to do in milliseconds after the start. This makes the timestamp possibly. The problem is that the way the video is recorded does not allow for a fixed frame time indication since it is not using a fixed frame rate to record the video.

Frame count not possible as timestamp

Chapter 7

Conclusion and future work

This thesis dealt with the topic of dark patterns, presenting an application that allows experts to record and create datasets of manipulative design elements on websites.

After the implementation of the application, the opportunity presented itself to do a user study, that gave valuable insights into how users perceive the application. The conducted user study identified some weaknesses and areas of improvement in the application. These findings serve as a foundation for future improvements and optimizations of the application to increase its effectiveness and user-friendliness. Particularly, the highlighted minor flaws and the presented possible solutions can be seen as starting points for future contribution to the application. Thus, making the workflows more intuitive and faster.

Study identified possible improvements

The study and Soe et al. [2022] also identified the problem of missing uniform definitions of dark patterns. The participants struggled to decide what dark patterns are present in the interface. The datasets produced in the study were very different. Furthermore, a potential feature, identified in this work, could further improve the richness of the produced datasets. While this feature has not been implemented currently, it presents a promising outlook for future developments. The feature of being able to draw boxes

Uniform definitions needed

Future feature: Draw boxes around dark patterns

around the identified dark patterns in the recording allows a more precise specification of the dark patterns. This was mentioned by two out of six participants in the user study and has also proven to be useful by Chen et al. [2023]. In addition to addressing the identified flaws, there exists a promising way for future work that could significantly enhance the capabilities of the application.

Future usage of the application

Not only improving the application can be part of future contributions, but also using it. Therefore a uniform definition of types of dark patterns is necessary. Creating consistent datasets of dark patterns, opens up the possibility of using them to train artificial intelligence. This could be used to create better automatic detection applications for dark patterns. Applications that could automatically draw warning signs close to dark patterns would also be conceivable. This would ultimately help in raising awareness and warning users about dark patterns.

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Index

abbrv, *see* abbreviation

code, 17
concept, 15
conclusion, 43

discussion, 35

evaluation, 29

future work, 43

implementation, 17

related work findings, 13