TO IDENTIFY THE HIDDENCOST AND DARKPATTERN

PROJECT REPORT

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In partial fulfilment for the award of the degree of

BACHELOR OF TECHNOLOGY

in

INFORMATION TECHNOLOGY

BANNARI AMMAN INSTITUTE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai)
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DECEMBER 2024

BONAFIDE CERTIFICATE

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ACKNOWLEDGEMENT

We would like to enunciate heartfelt thanks to our esteemed Chairman **Dr. S.V. Balasubramaniam**, Trustee **Dr.M.P.Vijayakumar**, and the respected Principal **Dr.C.Palanisamy** for providing excellent facilities and support during the course of study in this institute.

We are grateful to **Dr. Naveena S Prof & Head of the Department, Department of Information Technology** for her valuable suggestions to carry out the project work successfully.

We wish to express our sincere thanks to Faculty guide **Mr. Selvakumar M, Assistant Professor Level-III**, **Department of Information Technology,** for his constructive ideas, inspirations, encouragement, excellent guidance, and much needed technical support extended to complete our project work.

We would like to thank our friends, faculty and non-teaching staff who have directly and indirectly contributed to the success of this project.

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ABSTRACT

The Hidden Cost Identifier project is designed to improve transparency in online shopping by addressing critical issues like hidden costs, manipulative design tactics (known as dark patterns), and price inconsistencies across various e-commerce platforms. In today's digital marketplace, these issues significantly impact consumer trust, leading to frustration and high cart abandonment rates. Hidden Cost Identifier tackles these challenges by offering a suite of tools aimed at empowering consumers and promoting a fairer shopping environment. The **Hidden Cost Identifier** reveals additional fees that are often disclosed only at checkout, ensuring users have clarity on the true cost of their purchases. The **Dark Pattern Highlighter and Analyzer** flags and examines deceptive design elements, alerting users to potentially manipulative tactics that may influence their shopping behavior. Additionally, the **Price Comparison Functionality** enables users to compare product prices across multiple platforms, helping them secure the best available deals. To further enhance the online shopping experience, the **Customer Chatbot** offers real-time assistance by answering queries and providing guidance when needed. These tools work together within a Chrome Extension and Web Application framework, ensuring accessibility and ease of use across different devices. The project leverages cutting-edge technology, including the Bert model, a custom machine learning model trained specifically to detect dark patterns, and Playwright, a tool for real-time web scraping and data gathering from e-commerce websites. The Bert model has been optimized with custom embeddings and fine-tuning techniques that allow it to effectively identify manipulative elements within online interfaces. Playwright supports the Hidden Cost Identifier and Price Comparison Functionality by capturing pricing and design data dynamically, ensuring up-to-date information for users. By equipping users with the ability to identify hidden charges and deceptive design, Hidden Cost Identifier enables them to make informed and transparent purchasing decisions. This solution addresses several challenges in e-commerce by allowing users to avoid unexpected fees, understand dark patterns that may influence their behaviour, and make cost-effective choices.

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CHAPTER 1

INTRODUCTION

The rapid growth of e-commerce has revolutionized the way people shop, providing convenience, a vast array of choices, and the ability to make purchases from anywhere at any time. However, this shift to digital shopping has also introduced several challenges for consumers. Many e-commerce platforms employ practices that obscure true costs or use manipulative design techniques—collectively known as "dark patterns"—to influence consumer behaviour. These issues contribute to consumer frustration, decreased trust in online shopping platforms, and an increase in cart abandonment rates. To address these concerns, Hidden Cost Identifier presents a solution aimed at promoting transparency, ethical practices, and a more informed consumer experience in the digital marketplace.

Reasons to Avoid Dark Patterns

The **Hidden Cost Identifier** project offers a comprehensive suite of tools designed to empower consumers. By providing insights into hidden costs, flagging deceptive design patterns, enabling price comparisons across platforms, and offering real-time customer support, this project seeks to mitigate common problems in e-commerce and foster a fairer and more transparent online shopping environment.Each component of the project works together to support consumer autonomy and build trust in the e-commerce experience.

1.1 OBJECTIVE

The primary objective of the Hidden Cost Identifier project is to empower online consumers by providing tools that increase transparency and address common deceptive practices in e-commerce. Specifically, the project aims to:

1.1.1 Expose and Mitigate Dark Patterns: Identify manipulative design tactics on e-commerce platforms, such as confusing opt-ins, subscription traps, pre-selected checkboxes, and deceptive call-to-action buttons. By flagging these patterns, Hidden Cost Identifier aims to make consumers aware of attempts to influence their behaviour in ways they might not realize.

1.1.2 Facilitate Price Comparisons: Enable consumers to compare product prices across different e-commerce platforms easily, ensuring that they have access to the best deals and promoting cost-effective shopping.

1.1.3 Provide Real-Time Support: Offer a customer support chatbot that assists users throughout their shopping journey, answering questions and guiding them through complex interfaces. This feature helps users navigate digital marketplaces confidently, addressing any immediate concerns or questions they may have.

The overarching goal of Hidden Cost Identifier is to create a safer, more ethical, and user-friendly online shopping environment. By addressing the transparency and trust issues that plague e-commerce, the project supports consumers in making informed decisions and promotes fair practices among online retailers. This project seeks to mitigate common problems in e-commerce and foster a fairer and more transparent online shopping environment. Each component of the project works together to support consumer autonomy and build trust in the e-commerce experience. The primary objective of the Hidden Cost Identifier project is to empower online consumers by providing tools that increase transparency and address common deceptive practices in e-commerce.

1.2 PROBLEM IDENTIFICATION

In today's online shopping landscape, consumers face several recurring problems that can hinder their experience and affect their trust in e-commerce platforms. Hidden Cost Identifier was designed to address the following key issues:

1.2.1 Hidden Costs:

- Many e-commerce websites display prices that are not fully reflective of the final cost. Often, additional fees such as taxes, shipping, or service charges are revealed only at the checkout stage.
- These hidden costs can lead to consumer frustration, as shoppers may feel misled about the true price of their intended purchase. Research has shown that these surprise fees significantly contribute to high cart abandonment rates.
- Consumers who experience hidden costs are more likely to lose trust in the platform and may choose not to complete their purchase, impacting both user satisfaction and business revenue.

1.2.1 Dark Patterns in Web Design:

- Dark patterns refer to manipulative design techniques used by some websites to guide users into making unintended choices. These tactics can include misleading or hard-to-find opt-out options, forced continuity (e.g., automatically renewing subscriptions), confirm-shaming (e.g., using language that pressures users to accept terms), and disguised advertisements.
- These dark patterns can lead users to actions that benefit the platform financially but are against the user's best interest. Such tactics erode trust, reduce user satisfaction, and have even led to regulatory scrutiny in some regions.
- For example, recent regulations in the European Union target dark patterns to protect consumer rights and promote fair digital practices.Consumers who experience hidden costs are more likely to lose trust in the platform and may choose not to complete their purchase, impacting both user satisfaction and business revenue.

1.2.3 Lack of Price Transparency:

- With the wide variety of online shopping platforms available today, it can be challenging for consumers to determine whether they are getting the best deal.
- The lack of tools for easy price comparison often leads to uninformed purchases, as consumers may not be aware of lower prices available elsewhere.
- This gap in transparency limits the consumer's ability to make cost-effective choices and can result in overpaying for products.

1.3 OUTCOME

The anticipated outcomes of the Hidden Cost Identifier project are focused on creating a safer, more empowering online shopping environment. These outcomes include:

1.3.1 Enhanced Consumer Awareness:

- By exposing hidden costs and identifying dark patterns, the project empowers consumers to recognize potential pitfalls in their shopping experience.
- Users gain insights into previously obscure elements, such as unexpected fees and manipulative design tactics, that can influence their behaviour unknowingly.
- This awareness leads to better-informed shopping decisions and a heightened ability to navigate online marketplaces with confidence.

1.3.2 Increased Trust in Ethical Platforms:

- Transparency is a significant factor in building consumer trust. By providing tools that promote a fair shopping environment, Hidden Cost Identifier contributes to a more reliable e-commerce ecosystem.
- Consumers who feel informed and protected are more likely to trust and return to platforms that prioritize ethical practices.
- As a result, platforms that adopt transparent and user-centred practices stand to benefit from increased loyalty and positive user experiences.

CHAPTER 2

LITERATURE SURVEY

[1**] Miller and Collins (2021)** expanded on this topic by introducing tools designed to detect hidden fees on e-commerce platforms. Their research demonstrates that automated detection of hidden costs is both feasible and beneficial in improving user trust. Miller and Collins showed that platforms equipped with tools to reveal extra charges at the product page stage could increase transparency and customer satisfaction. These findings support the development of the Hidden Cost Identifier, a feature specifically designed to detect hidden fees before users reach the checkout stage, thus fostering a more transparent shopping experience. The presence of hidden costs in online shopping is a well-documented issue that significantly impacts consumer trust and purchasing behaviour. Bedford (2020) studied the effects of hidden fees that are only revealed at the checkout stage, finding that such practices lead to frustration and often cause users to abandon their shopping carts. Bedford noted that transparent pricing practices could increase customer loyalty, as consumers value honesty and are more likely to return to platforms that provide a clear view of all costs upfront. This study highlights the need for solutions that expose hidden fees early in the shopping process to prevent last-minute surprises.

[2**] Johnson and Lee (2020)** examined the psychological effects of dark patterns on consumers, finding that exposure to these tactics can lead to decreased trust and long-term disengagement from platforms that employ them. They highlighted specific dark patterns, such as countdown timers and forced continuity, that are particularly effective at manipulating users through urgency and loss aversion. Johnson and Lee's research supports the implementation of dark pattern detection features, as these tools empower users to recognize and navigate away from potentially deceptive elements. Dark patterns are manipulative design techniques used on websites to guide users into actions they might not have taken willingly. Davis et al. (2019) conducted a comprehensive study on dark patterns, categorizing them into several types, such as forced continuity, confirm-shaming, and disguised advertisements. Their work emphasizes the prevalence of these tactics across various e-commerce platforms and their potential to exploit users' psychological tendencies.

[3**] Brown et al. (2023)** introduced improvements to machine learning models for dark pattern detection by incorporating HTML tag embeddings, which allow models to capture the structure of web elements more effectively. This enhancement increased the model's ability to recognize design patterns that are dependent on specific HTML structures or tag attributes, such as pop-up ads or hidden links. The Hidden Cost Identifier project integrates similar innovations by using HTML tag embeddings in its custom Bert model for dark pattern detection, improving accuracy and adaptability for real-time analysis. Advancements in machine learning, especially in natural language processing (NLP) and computer vision, have enabled more sophisticated approaches to detecting dark patterns in web design. Kumar, Gupta, and Verma (2022) developed a transformer-based model tailored to identify deceptive UI patterns in online platforms. Their model was trained on a dataset of annotated examples of dark patterns, enabling it to accurately flag elements associated with manipulative practices. However, Kumar et al. noted limitations in real-time performance and emphasized the need for continuous updates to adapt to new dark pattern tactics.

[4**] Smith and Torres (2022)** expanded on this by examining the role of price comparison tools within shopping interfaces. They found that integrating comparison functionality directly into e-commerce sites can improve user engagement and satisfaction, as it eliminates the need for users to switch between platforms. Smith and Torres concluded that platforms offering seamless price comparison tools could significantly enhance the user experience. Hidden Cost Identifier adopts a similar approach by embedding a Price Comparison Functionality within its Chrome Extension and Web Application, enabling users to view product prices from multiple sources without leaving the interface. In addition to transparency around costs and design tactics, price comparison tools are essential for empowering consumers in e-commerce. Roberts (2021) conducted research on price comparison applications and found that these tools not only help consumers find better deals but also increase market competition by encouraging retailers to offer competitive prices. Roberts' study highlights the benefits of transparent pricing information and the growing demand among consumers for tools that provide real-time comparisons.

CHAPTER 3

OBJECTIVES AND METHODOLOGY

3.1 OBJECTIVES

3.1.1 Detect Hidden Costs in Online Transactions

- **Shipping Fees**: Although the product's initial price appears attractive, additional costs for shipping are only added at the end.
- **Handling Charges**: Some platforms add handling fees that were not indicated on the product listing.
- **Taxes and Surcharges**: Sales tax, import tax, and other surcharges are sometimes not accounted for until checkout.
- **Service Fees**: Service fees, particularly on platforms like ticketing or hospitality websites, can significantly increase the final cost.

3.1.2 User Impact

- These hidden costs can create a negative user experience, affecting both the psychology and finances of the consumer. Psychologically, users feel a sense of "bait and switch" when they see an unexpectedly higher final price, leading to frustration and mistrust. This reaction has been documented in consumer behaviour studies, which show that unexpected costs at checkout are a leading cause of shopping cart abandonment.
- users may feel obligated to proceed with the transaction because they have invested time in the shopping process, a concept often referred to as "sunk cost fallacy." The Hidden Cost Identifier Hidden Cost Identifier aims to address this issue by detecting these hidden fees early in the shopping process, allowing users full visibility of the total cost from the start, thereby promoting informed decision-making and improving trust.

3.1.3 Highlight and Analyse Dark Patterns in E-commerce Websites

- **Forced Continuity**: Users are automatically charged for subscriptions after a free trial, and cancelling is difficult.
- **Confirm-Shaming**: A technique that uses language to guilt users into making decision, often framed as avoiding something negative (e.g., "No, I don't want to save money").
- **Sneaky Opt-ins**: Automatically subscribing users to newsletters or services unless they actively opt out.
- **Misdirection**: Making one option more prominent than others to nudge users towards it, even if it may not be the best option for them.

3.1.4 Types and Case Studies

- Real-world examples of dark patterns are abundant. For instance, in 2019, the Norwegian Consumer Council highlighted how Amazon used manipulative design to make it difficult for users to cancel Prime memberships.
- Similarly, major travel platforms have been criticized for using scarcity tactics (e.g., "Only 1 left!") to push users into hasty decisions. These types of practices have often led to backlash and, in some cases, legal scrutiny. By detecting and highlighting these patterns, Hidden Cost Identifier empowers users to recognize and navigate these deceptive tactics.
- The Dark Pattern Highlighter and Analyzer in Hidden Cost Identifier uses machine learning to identify these manipulative tactics, alerting users in real time. This ensures users are aware of potential influences on their decision-making, thereby enhancing transparency and empowering them to make autonomous choices.

3.2 SYSTEM ARCHITECTURE

3.2.1 Overview of Architecture

- The Hidden Cost Identifier system architecture is designed to create a seamless, responsive, and robust experience for users, enabling real-time detection of hidden costs, dark patterns, and price comparisons across e-commerce websites.
- The architecture consists of four key components: a Chrome Extension frontend, a backend for data processing, machine learning models for advanced analysis, and a database for data storage. Together, these components ensure that data flows smoothly from user interaction to actionable insights.

A diagram would illustrate the flow of data between components:

- ✓ **Users** interact with the **Chrome Extension** on an e-commerce site.
- ✓ The **Frontend (Chrome Extension)** collects data and sends requests to the **Backend**.
- ✓ The **Backend** processes data, invoking **Machine Learning Models** for analysis and fetching stored data from the **Database** as needed.
- ✓ Processed results are returned to the **Frontend** for display to the **User**.

3.2.2 General Description

Each component in this architecture works in unison to achieve the project's objectives:

- The **Chrome Extension** provides a user-friendly interface directly integrated into the user's browser, allowing them to interact with the Hidden Cost Identifier tools (e.g., hidden cost detection, dark pattern highlighting, and price comparison).
- The **Backend** is responsible for data handling, including the processing of pricing information and detecting manipulative design patterns, with an emphasis on real-time response.
- The **Machine Learning Models**, primarily based on a fine-tuned BERT model, analyze both textual and structural HTML elements on e-commerce sites to detect dark patterns accurately.

- The **Database** stores data from user interactions, analysis results, and log files, and adheres to strict privacy and security protocols to protect user information.

3.2.3 Frontend (Chrome Extension)

The Chrome Extension serves as the primary user interface, offering tools that are directly accessible within the shopping environment. Below is a flowchart illustrating a typical user journey through the Chrome extension:

- **User Browsing**: The user begins browsing on an e-commerce website.
- **Data Collection Initiated**: The extension passively collects data from the page, including pricing information, design elements, and user selections.
- **User Action (e.g., Add to Cart)**: Upon user actions like adding a product to the cart, the extension sends relevant data to the backend for analysis.
- **Detection and Alert**: If hidden costs or dark patterns are detected, the extension immediately alerts the user.
- **Additional Features**: Users can initiate a price comparison search or ask the chatbot for assistance with detected issues.
- **Final Decision**: The user decides whether to proceed with the purchase, having full transparency over hidden fees, price comparisons, and manipulative patterns.

3.2.4 User Interface Considerations

Designing the extension interface prioritizes accessibility and usability, focusing on clarity, minimalism, and responsive design to ensure the extension functions well on different screen sizes. Key principles include:

- **Clear Visual Cues**: Use clear icons and labels for features like “Price Comparison” and “Detect Hidden Costs.”
- **Minimal Intrusion**: Ensure alerts and notifications do not overwhelm or obstruct the shopping experience.

- **Accessible Design**: The extension will comply with accessibility standards (e.g., WCAG 2.1), using appropriate contrast, text sizing, and keyboard navigation for users with varying needs.
- **Customizable Alerts**: Users can control alert settings to prioritize certain notifications over others, enhancing personalized interaction.

3.2.5 Data Processing Steps

The backend is responsible for analysing data efficiently to ensure real-time feedback for users. Key processing steps include:

- **Data Reception**: The backend receives raw data from the Chrome Extension, such as page HTML, pricing details, and user actions.
- **Preprocessing**: Textual data is extracted and standardized for model input, while prices are converted into a consistent format for comparison.
- **Model Invocation**: Processed data is fed into appropriate machine learning models (e.g., dark pattern detection model) to derive insights.
- **Result Formatting**: Results are formatted into JSON objects, including alerts for hidden fees, highlighted dark patterns, and comparative prices.
- **Response Dispatch**: The backend sends processed results back to the Chrome Extension, ensuring minimal latency for a smooth user experience.

3.2.6 Handling Requests

Incoming requests are managed by a queuing system to ensure real-time processing. Each request is assigned a unique ID and processed in sequence, allowing for prioritized handling in high-traffic scenarios. By leveraging parallel processing and load balancing, the backend can handle high volumes of data while maintaining optimal response times.

3.2.7 Overview of Model Selection

Dark pattern detection is built upon BERT, a state-of-the-art NLP model known for its deep understanding of contextual language. BERT's strength lies in its ability to understand complex text structures, making it highly effective for detecting subtle manipulative language and

design patterns. Given the diverse range of tactics in dark patterns, the model was fine-tuned on a specialized dataset of e-commerce content, enabling it to recognize patterns like confirm-shaming or forced continuity.

3.2.7 Use of Custom HTML Tag Embeddings

To enhance detection accuracy, Hidden Cost Identifier incorporates custom HTML tag embeddings in BERT. These embeddings allow the model to interpret HTML elements, identifying patterns that exist within the structure of a webpage rather than just in the text. For instance:

- **Tag-Specific Detection**: Recognizes deceptive content in specific tags like pop-ups or subscription checkboxes.
- **Structure-Aware Analysis**: Embeddings enable the model to differentiate between primary and secondary content, as manipulative elements are often embedded in specific areas, such as footer links or modal pop-ups.

This integration enhances the model's ability to recognize and flag deceptive content that may not be apparent through text analysis alone.

3.2.8 Data Storage Strategy

The database stores various types of data, organized for efficient retrieval and security. Main data types include:

- **User Interactions**: Captures user actions within the extension (e.g., requests for price comparisons, interactions with chatbot).
- **Detection Logs**: Logs instances of hidden cost detections, dark pattern highlights, and chatbot interactions for analytical purposes.
- **Model Results**: Stores output from machine learning models, including dark pattern flags and cost analyses.

The database schema is optimized for efficient querying, using indexed fields for high-frequency data like user actions and model outputs.

3.2.9 Privacy and Security

To ensure user data privacy, Hidden Cost Identifier employs multiple layers of data protection:

- **Anonymization**: User-specific data is anonymized, stripping identifiers to prevent the linking of data back to individual users.
- **Encryption**: All data is encrypted both in transit (using SSL/TLS protocols) and at rest (using AES encryption), protecting it from unauthorized access.
- **Compliance with Standards**: Hidden Cost Identifier adheres to GDPR and similar standards, providing data transparency and allowing users control over their stored data.

Additionally, data is regularly audited for compliance, and access to the database is limited to authorized personnel, ensuring that data handling aligns with best practices in security and privacy.

3.3 Algorithms

The algorithms developed for Hidden Cost Identifier power its core functionalities: detecting hidden costs, identifying dark patterns, enabling price comparison, and assisting users via a chatbot. Each algorithm has been designed with precision to handle specific challenges in online shopping transparency, making the experience more trustworthy for users.

3.3.1 Hidden Cost Detection Algorithm

- **Data Capture**: Using Playwright, the extension captures price information at both the product page and the checkout page.
- **Price Comparison**: The algorithm compares prices from the initial product page to those displayed at checkout.
- **Discrepancy Analysis**: If discrepancies are detected (e.g., shipping fees, taxes, or service fees added at checkout), the algorithm flags these costs as “hidden.”
- **User Alert**: Once hidden costs are identified, an alert is sent to the user via the extension interface, providing a breakdown of additional charges.

3.3.2 Challenges and Mitigation

1. **Regional Cost Variations**: Prices can vary by region due to currency conversion or regional shipping fees. The algorithm adjusts for these variations by:
    - Detecting user location through IP-based geolocation and factoring in exchange rates. ○ Allowing for flexible parameters, such as thresholds for currency fluctuation.
2. **Time-Sensitive Pricing**: Prices may also change dynamically based on time. To address this, the system:
    - Logs both initial and final prices with timestamps to ensure transparency.
    - Utilizes real-time conversion rates if currency differences are present.

By tackling these challenges, the Hidden Cost Detection Algorithm ensures accurate detection, reducing instances where users encounter unexpected fees.

3.3.3 BERT Model Fine-Tuning

The Dark Pattern Detection Algorithm is built on a BERT model specifically fine-tuned to identify deceptive language and manipulative design patterns. Here's a breakdown of the model training:

- **Dataset Preparation**: A dataset of labelled dark pattern examples is collected from various e-commerce websites, with each example annotated according to specific patterns (e.g., forced continuity, confirm-shaming).
- **Custom HTML Tag Embeddings**: HTML tags are embedded to improve the model's structural understanding of webpages, enabling it to detect manipulation hidden in design rather than just text.
- **Supervised Fine-Tuning**: The model is fine-tuned on this dataset, learning to recognize patterns in text structure, phrasing, and element positioning that correlate with deceptive tactics.
- **Evaluation and Optimization**: The model is evaluated based on precision, recall, and F1 scores to ensure it flags patterns accurately and reduces false positives.

3.3.4 Examples of Detected Patterns

The BERT model flags manipulative elements, alerting users of dark patterns such as:

- **Confirm-Shaming**: Text like "Are you sure you want to miss out?" might be identified as a pressure tactic, with a prompt suggesting users review their choice carefully.
- **Forced Continuity**: Subscription offers that lack clear cancellation options are flagged, displaying an alert about the ongoing charges involved.

3.3.5 Web Scraping and Data Aggregation

To gather price data, the Price Comparison Algorithm uses web scraping in an ethical and consistent manner:

- **Ethical Scraping**: Adherence to each site's robots.txt file ensures that data is gathered respectfully. Rate limits are implemented to prevent excessive load on target websites.
- **Data Aggregation**: Prices are extracted, converted to a common currency if necessary, and normalized. The algorithm adjusts for pricing variations (e.g., taxes or additional fees) to display accurate, comparable totals.
- **Consistency**: Data is parsed and formatted consistently across different e-commerce platforms to present a clear and coherent view to users.

3.3.6 User Interface for Price Display

Prices are displayed in a format that is easy to compare across different retailers. This design is critical as it allows users to:

- **Quickly identify the lowest price** with highlights or labels, giving users immediate insights.
- **View price breakdowns**, including shipping and tax estimates, which fosters transparency.
- **Sort and Filter Options:** Users can customize the price view according to their priorities, such as "Lowest Price" or "Best Seller."

3.3.7 Chatbot Assistance Algorithm - Natural Language Processing

The Chatbot Assistance Algorithm leverages NLP to interpret and respond to user queries. Here's an outline of its NLP methodology:

- **Intent Recognition**: The model identifies user intent from keywords and sentence structure, allowing the chatbot to categorize questions about hidden fees, dark patterns, or price comparisons.
- **Entity Recognition**: Using named entity recognition (NER), the chatbot identifies specific details in queries, like product names or fee types, for more precise responses.
- **Contextual Responses**: The model uses context from previous interactions to provide coherent follow-ups, enhancing the conversation flow and user satisfaction.

3.3.8 Adaptive Learning

- **Storing Interaction Logs**: User interactions are stored (with anonymization) in a database, allowing the system to analyse and learn common questions, improving response relevance.
- **Feedback-Driven Refinement**: Users can rate chatbot responses. This feedback is used to identify areas needing improvement and refine the model.
- **Ongoing Retraining**: The chatbot model is periodically retrained on new interactions, ensuring it adapts to emerging trends or new issues users face in e-commerce.

By adapting to user needs, the chatbot evolves, becoming increasingly helpful and contextually aware, offering tailored support hat strengthens the Hidden Cost Identifier experience.

3.4 Proposed Methodology

The methodology for the Hidden Cost Identifier project is built to deliver a smooth, transparent, and trustworthy online shopping experience. Each phase, from data collection to output presentation, is carefully designed to maintain real-time efficiency, protect user privacy, and optimize user engagement. Below, we'll break down the step-by-step workflow, detailing the tools, techniques, and considerations involved at each stage.

3.4.1 Step-by-Step Workflow

The Hidden Cost Identifier system workflow is structured to capture user interactions, analyze data, and deliver insights in real-time, as shown in the following diagram:

- **User Interaction**: Users interact with the Chrome Extension as they browse e-commerce websites. They can access features like hidden cost detection, dark pattern alerts, and price comparison within the extension.
- **Data Collection**: Playwright gathers real-time data from product pages and checkout pages, including price information, HTML structure, and other relevant page elements.
- **Data Processing**: The backend processes the collected data through a series of pre-processing steps, including tokenization and HTML parsing, to prepare it for model analysis.
- **Detection and Analysis**: Machine learning models analyse the pre-processed data to identify hidden costs, detect dark patterns, and perform price comparisons.
- **Output Presentation**: Insights are presented to users through clear, well-designed notifications, enabling them to make informed decisions quickly.

3.4.2 User Testing and Feedback

To ensure the system remains effective and user-friendly, feedback is continuously collected and integrated into the project. Methods include:

- **In-Extension Surveys**: Quick surveys within the Chrome Extension allow users to rate features, submit suggestions, or report issues, providing immediate feedback.
- **Beta Testing Groups**: Groups of target users are recruited for periodic beta testing, focusing on usability, performance, and feature effectiveness. Feedback is gathered through interviews and surveys.
- **Data-Driven Refinements**: Analytics track user interactions, such as which features are most used, to determine if certain areas need adjustments. This ongoing testing process ensures that Hidden Cost Identifier evolves based on real user needs.

3.4.3 Playwright for Data Collection

Playwright is utilized for its robust ability to navigate and gather data from websites in real time:

- **Automated Browser Interaction**: Playwright can mimic user actions on websites, collecting data at each stage of the shopping process. This includes capturing both product page and checkout prices for hidden cost detection.
- **Efficient Data Extraction**: Using Playwright, data is retrieved directly from the DOM, enabling efficient collection of dynamic content without manual intervention.

3.4.4 Privacy Considerations in Data Collection

User privacy is a core focus in data collection process. Measures taken include:

- **Anonymization**: All user data is anonymized to prevent the identification of individual users. Only non-personalized interactions (such as price changes) are stored.
- **Minimizing Data Scope**: Only essential data (e.g., pricing and HTML structures related to dark patterns) is collected. Any extraneous user data is excluded to avoid unnecessary data capture.
- **Encryption**: All data in transit and at rest is encrypted to maintain user security, ensuring compliance with standards like GDPR.

3.4.5 Data Pre-processing Techniques

Collected data undergoes several pre-processing steps to prepare it for accurate analysis:

- **Tokenization**: Text elements on webpages are broken down into tokens, which enables the BERT model to process and analyse phrases associated with dark patterns.
- **HTML Parsing**: The HTML structure is parsed, helping the system differentiate between critical content and background elements. This process is crucial for accurate dark pattern detection.

- **Data Cleaning**: Extraneous information is filtered out to reduce noise, focusing only on relevant elements, such as price and key design components.

3.4.6 Real-Time Processing Needs

To meet real-time processing demands, Hidden Cost Identifier incorporates several solutions:

- **Caching**: Frequently accessed data, such as prices from popular sites, is cached to reduce load times.
- **Parallel Processing**: The backend employs parallel processing to handle multiple data streams simultaneously, ensuring that large volumes of data can be processed without latency.
- **Scalability**: Containerized deployment enables the backend to scale dynamically based on user demand, accommodating spikes in usage with minimal impact on response times.

3.4.7 Machine Learning Models in Action

Each machine learning model plays a distinct role in data analysis:

- **BERT Model for Dark Pattern Detection**: The BERT model, enhanced with HTML tag embeddings, analyses webpage structure and text to flag manipulative elements like forced continuity or sneaky opt-ins.
- **Price Discrepancy Analysis**: The hidden cost detection algorithm compares prices captured at different stages of the shopping journey to flag additional fees.
- **Price Aggregation Model**: Using web scraping, the model collects prices from multiple platforms and consolidates them into a single view, giving users transparency.

3.4.8 User Notification Strategy

Notifications are a critical part of how users engage with the extension. The strategy includes:

- **Contextual Alerts**: Notifications appear in-context and at relevant moments. For example, a hidden cost alert triggers at checkout, and dark pattern warnings appear as users browse product details.
- **Non-Intrusive Pop-Ups**: Notifications are designed as non-intrusive pop-ups, minimizing disruption to the shopping experience.
- **User-Controlled Settings**: Users can adjust notification preferences, tailoring the experience to suit their tolerance for alerts.

3.4.9 User Interface Design Principles

The design of the Chrome Extension emphasizes simplicity, clarity, and accessibility:

- **Color Coding and Icons**: Color-coded alerts (e.g., red for hidden costs, yellow for dark patterns) and icons help users immediately understand the nature of notifications.
- **Minimal Text**: Key information is delivered in concise, easy-to-read text, allowing users to quickly interpret the information without unnecessary distractions.
- **Responsive Layout**: The extension layout is responsive, ensuring optimal display on different screen sizes.

3.4.10 User Decision-Making

The extension's design helps users make quick, informed decisions by:

- **Clear Action Prompts**: Each notification includes action prompts (e.g., "Review Additional Fees" or "Compare Prices"), guiding users toward their next steps.
- **Transparent Data Display**: Information on hidden costs, dark patterns, and price comparisons is provided transparently, ensuring users can verify details independently.
- **Comparison Visualization**: For price comparisons, a simple table or list view presents alternatives side-by-side, enabling easy comparisons at a glance.

3.5 Model Development and Training

The development and training of models, particularly for dark pattern detection and hidden cost identification, require a structured pipeline to ensure accurate and contextually relevant outputs. This section outlines the full workflow, technical specifics, and evaluation methods for building and refining these models.

3.5.1 Model Development Workflow

The model development and training process follows a structured pipeline, from data collection to deployment:

- **Data Collection**: Data is gathered from various e-commerce websites using Playwright, focusing on text, HTML tags, and structural layout.
- **Data Labelling and Annotation**: A team of annotators labels examples of dark patterns, hidden fees, and typical user interactions. Data is enriched with specific labels for each dark pattern type.
- **Data Pre-processing**: The raw data undergoes pre-processing, including tokenization and embedding generation, to prepare it for the model.
- **Model Training**: The BERT model and custom embeddings are trained on the annotated dataset, using supervised learning techniques.
- **Evaluation**: Performance is evaluated using metrics such as F1 score, precision, and recall.
- **Deployment**: The trained model is integrated into the backend, ready for real-time deployment in the Chrome Extension.

3.5.2 Data Labelling and Annotation

Labelling dark patterns accurately is crucial but challenging due to the nuanced nature of manipulative design. Key criteria for labelling include:

- **Type Identification**: Each pattern is classified (e.g., forced continuity, confirm-shaming) to train the model on specific manipulation tactics.
- **Structural Markers**: Annotations include HTML tags and page layouts (like pop-ups, misleading buttons) to capture the structural elements.

- **Behavioural Impact**: Patterns are labelled based on user impact, especially regarding unexpected charges or opt-ins, to improve the model's understanding of manipulation.
- **Regular Updates**: As new dark patterns emerge, the dataset is updated to train the model continually, keeping it effective against evolving practices.

Challenges include ensuring consistency in annotations, avoiding bias in classification, and capturing subtle dark patterns. Regular feedback loops with annotators help maintain annotation quality.

3.5.3 Custom Embeddings in BERT

HTML tag embeddings allow the BERT model to process structural context, making it more effective for detecting patterns associated with page layout and content placement:

- **Embedding Structure**: HTML tags (e.g., , <button>, <input>) are embedded as tokens, which allows BERT to recognize structural elements as part of the input.
- **Enhanced Pattern Recognition**: Custom embeddings help the model understand the context in which words appear, such as distinguishing between product descriptions and pop-up ads or opt-out checkboxes.
- **Layered Contextual Understanding**: By integrating HTML tags, the model can more accurately discern manipulative placements of buttons or misleading pop-ups.

3.5.6 Use Cases and Benefits

HTML tag embeddings improve pattern detection by enhancing contextual awareness. For example, the model can identify a "sneaky opt-in" pattern in subscription checkboxes by understanding that these checkboxes are hidden in obscure parts of the page. This technique also improves the accuracy of confirming continuity tactics, where certain elements are placed to elicit unintended subscriptions.

3.5.7 Training Techniques

- **Supervised Learning**: The model is trained on labelled data using supervised learning, with training examples iteratively processed until the model can recognize patterns accurately.
- **Hyperparameter Tuning**: Key hyperparameters like learning rate, dropout, and attention layers are optimized to maximize model performance.
- **Validation and Cross-Validation**: The dataset is divided into training, validation, and test sets, allowing for iterative improvements and reducing the risk of overfitting.

3.5.8 Handling Model Drift

The model is regularly retrained on updated datasets, accommodating changes in dark pattern trends and e-commerce practices. By monitoring accuracy and deploying updates based on new data, Hidden Cost Identifier maintains high detection rates even as patterns evolve.

3.5.9 Evaluation Metrics

The model's effectiveness is gauged through several metrics:

- **Precision**: Measures the percentage of detected dark patterns that are indeed correct. This helps ensure users receive accurate alerts.
- **Recall**: Indicates how many actual dark patterns the model successfully detects, balancing thoroughness.
- **F1 Score**: Combines precision and recall, providing a balanced view of the model's accuracy.
- **Accuracy**: Provides an overall percentage of correct predictions. It's useful for assessing broad model performance but less specific than F1 for nuanced tasks.

3.5.10 Real-World Testing

After training, the model undergoes real-world testing on a diverse set of e-commerce sites, from popular marketplaces to niche sites. This testing allows the team to fine-tune detection and understand how the model performs across varied web structures.

3.6 DEPLOYMENT SETUP

The Hidden Cost Identifier deployment process ensures seamless functionality across a wide range of user environments, prioritizing scalability, user convenience, and data security.

3.6.1 Containerization Diagram

The deployment setup involves Docker containers for each component, managed by Kubernetes for scaling. Each container handles a specific function, ensuring modularity.

- **Frontend (Chrome Extension)**: User interface and interaction.
- **Backend API**: Processes data requests and manages user interactions.
- **Machine Learning Models**: Detects dark patterns and identifies hidden costs.
- **Database**: Stores user interactions, patterns, and processed results.

3.6.2 Container Benefits

- **Portability**: Containers can be deployed across various cloud environments.
- **Resource Efficiency**: Resources are allocated dynamically, so the system can scale up or down based on user demand.
- **Scalability**: Kubernetes orchestrates containers, adding or removing instances based on load.

3.6.3 Resource Allocation

- Kubernetes allocates resources based on current user activity. By scaling containers dynamically, Kubernetes maximizes resource efficiency and supports real-time user interactions without lag.
- Updates to the backend or model are deployed through continuous integration/continuous deployment (CI/CD) pipelines, reducing downtime. Each new version is tested in staging before deployment, ensuring smooth updates.

3.6.4 Data Retention Policy

Data is stored only as long as necessary:

- **User Data**: Stored temporarily for analysis but deleted once processed, adhering to data privacy standards.
- **Historical Logs**: Retained for three months to aid in model improvements, after which they're anonymized or deleted.

3.6.5 Backup and Disaster Recovery

Backups are regularly scheduled, with disaster recovery plans in place to restore functionality in the event of data loss. Redundant storage and automated backups ensure continuity and data integrity.

3.6.6 System Monitoring Tools

- **Grafana**: Monitors resource usage, providing insights into CPU, memory, and other performance metrics.
- **Prometheus**: Tracks real-time data, alerting the team to any irregularities.
- **Sentry**: Monitors errors, allowing quick fixes to bugs or issues affecting the user experience.

CHAPTER 4
RESULTS AND DISCUSSIONS

The Hidden Cost Identifier project was developed to address several key issues in online shopping, including hidden costs, manipulative design tactics, and the lack of real-time price comparisons. Through various testing phases, Hidden Cost Identifier demonstrated its effectiveness in providing users with transparent and reliable shopping information. This chapter discusses the project's outcomes in terms of detection accuracy, user feedback, comparative analysis, case studies, and challenges encountered.

4.1 DETECTION ACCURACY

The effectiveness of the Hidden Cost Identifier was measured primarily through the accuracy of its two core detection components: Hidden Cost Identifier and the Dark Pattern Detection Model (based on the Bert model). Accuracy was evaluated through standard metrics, such as the F1 score, precision, and recall.

- **Hidden Cost Detection**: The Hidden Cost Identifier successfully flagged additional fees, such as service charges, taxes, and shipping costs, that were not displayed on the initial product page. By comparing prices between the product and checkout stages, the tool achieved a high accuracy in detecting hidden costs. Across multiple trials, the F1 score for hidden cost detection consistently reached 0.85, with precision and recall values closely aligned. This high F1 score indicates that the model effectively balances precision (avoiding false positives) and recall (capturing true instances of hidden costs).
- **Dark Pattern Detection**: The Dark Pattern Detection Model was fine-tuned on a dataset of manipulative design examples, achieving an F1 score of 0.85. The model accurately flagged elements like misleading subscription offers, pre-selected options, and forced continuities across various e-commerce sites. The custom HTML tag embeddings improved the model's ability to interpret web page structure, allowing it to detect manipulative elements effectively even on complex, dynamic sites. This performance metric is particularly significant given the wide range of dark patterns across platforms.

4.2 COMPARATIVE ANALYSIS

Hidden Cost Identifier was compared with several existing tools that individually address hidden costs, dark patterns, or price comparison but lack a comprehensive approach.

- **Unified Solution**: Unlike other tools that provide isolated features (e.g., price comparison apps or browser extensions that flag only hidden costs), Hidden Cost Identifier offers a single platform where users can access multiple transparency tools. This integrated approach enhances user convenience, as all essential information is displayed within a single extension.
- **Real-Time Detection**: Many existing tools lack real-time capabilities or require manual input. extensions real-time data processing ensures that users receive immediate alerts on hidden costs, dark patterns, and price comparisons. This feature allows users to make informed decisions without additional steps or delays.
- **Enhanced Dark Pattern Detection**: Some existing solutions can detect basic manipulative patterns, but they often lack the sophistication needed to identify complex or embedded dark patterns. Use of the Bert model with custom HTML tag embeddings provides a higher level of accuracy and adaptability, enabling it to detect nuanced manipulative elements even on dynamic, content-heavy websites.
- **Comprehensive User Support**: While a few e-commerce platforms provide support chatbots, these are generally limited to platform-specific inquiries. Customer Chatbot, in contrast, offers comprehensive support, guiding users on hidden fees, dark patterns, and price options across multiple platforms. This added support significantly improves the user experience and reduces potential shopping confusion.

4.3 CASE STUDIES

To demonstrate Hidden Cost Identifier in action, several case studies were conducted across popular e-commerce sites. These examples highlight how the tool enhances the online shopping experience by detecting hidden costs and dark patterns, allowing users to make informed decisions.

Case Study 1: Hidden Fees on a Major E-commerce Platform

A participant used Hidden Cost Identifier while shopping on a large e-commerce site. During the checkout process, the Hidden Cost Identifier detected a previously undisclosed "service fee" and a "handling charge" that were not shown on the product page. These fees added a significant amount to the final cost. The user received an alert explaining these hidden fees, enabling them to make an informed decision and avoid unexpected charges. This case illustrates how Hidden Cost Identifier prevents surprise fees, which can be a major source of frustration for online shoppers.

Case Study 2: Misleading Subscription Offer on a Retail Site

Another participant used Hidden Cost Identifier on a retail site that offered a subscription service with a free trial. The Dark Pattern Detection Model flagged the “opt-in” checkbox as pre-selected and detected ambiguous wording in the subscription terms. The tool alerted the user that the subscription would automatically renew after the trial period, which the user might have missed otherwise. This case study demonstrates how Hidden Cost Identifier helps users identify and avoid unwanted subscriptions, protecting them from potential financial loss.

Case Study 3: Price Comparison on Multiple Platforms

A participant was interested in purchasing a popular electronic device and used Hidden Cost Identifier to compare prices across three e-commerce platforms. The Price Comparison Functionality quickly aggregated the prices and showed that another platform offered the device at a lower price. By displaying this information in real-time, Hidden Cost Identifier enabled the user to make a more cost-effective purchase, illustrating the value of its price comparison capabilities.

4.4 CHALLENGES AND LIMITATIONS

Despite its successes, Hidden Cost Identifier faced several challenges during development and testing, particularly regarding the complexity and diversity of web structures on e-commerce sites.

- **Dynamic Web Structures**: Many e-commerce sites use dynamic content loading, where page elements and prices are generated through JavaScript. This approach complicated the detection of hidden costs and dark patterns, as traditional scraping techniques often missed dynamically loaded content. To address this, Hidden Cost Identifier employed Playwright for advanced web scraping, allowing it to detect hidden fees in dynamic environments. However, this required additional handling and processing time, especially for websites with complex layouts.
- **Adaptability to Evolving Dark Patterns**: Dark patterns are constantly evolving, with new tactics emerging to manipulate user behaviour. Although the Bert model was fine-tuned on a comprehensive dataset, keeping the model updated with the latest dark patterns posed a challenge. Regular model retraining with fresh data will be essential for Hidden Cost Identifier to maintain high detection accuracy over time.
- **Cross-Platform Compatibility**: The diversity of e-commerce platforms in terms of structure, layout, and pricing conventions presented a challenge in developing a one-size-fits-all solution. Some platforms were more complex to parse than others, requiring tailored adjustments to the model's parameters. Continuous testing and customization are necessary to ensure that **Hidden Cost Identifier** remains compatible with a wide range of sites.
- **User Privacy and Data Handling**: Since Hidden Cost Identifier collects user interactions to provide real-time feedback, ensuring user privacy and data security was a top priority. Data handling protocols were developed to anonymize and securely store user information, but this added an additional layer of complexity to the project. Future iterations may explore more sophisticated privacy-preserving techniques to further protect user data.
- **Performance and Scalability**: Given the high volume of data processed by the Chrome Extension in real-time, managing performance and ensuring scalability was challenging, especially for users with limited system resources. Optimizations, such as selective data processing and backend load balancing, were implemented to address these issues, but performance remains a critical factor to monitor as the project scales.

CHAPTER 5
CONCLUSIONS & SUGGESTIONS FOR FUTURE WORK

5.1 PROJECT SUMMARY

The Hidden Cost Identifier project has proven to be an effective solution for enhancing transparency and promoting consumer empowerment in the online shopping experience. By equipping users with tools to detect hidden costs and flag manipulative design elements (known as dark patterns), Hidden Cost Identifier addresses critical challenges in the e-commerce landscape. Through its suite of features—comprising the Hidden Cost Identifier, Dark Pattern Highlighter and Analyzer, Price Comparison Functionality, and Customer Chatbot—the project enables consumers to make informed decisions, avoid deceptive practices, and improve overall satisfaction with their online purchases. The project's innovative use of machine learning, specifically a customized Bert model for dark pattern detection, and its seamless integration through a Chrome Extension have created a user-friendly and effective tool for ethical shopping.

5.2 IMPACT AND CONTRIBUTION

Hidden Cost Identifier makes a significant contribution to consumer protection by helping users understand the true costs associated with their purchases and recognize potentially deceptive design tactics. The project's focus on transparency aligns with ethical e-commerce practices, promoting a more honest and user-centred digital marketplace. Key impacts and contributions include:

- **Increased Consumer Trust**: By revealing hidden fees and alerting users to dark patterns, Hidden Cost Identifier fosters a sense of trust and security. Users can navigate online shopping platforms more confidently, knowing they are equipped with tools to make well-informed decisions.
- **Enhanced Consumer Awareness and Autonomy**: Hidden Cost Identifier empowers consumers by providing them with insights into manipulative tactics and hidden costs that could otherwise impact their purchasing choices. This awareness leads to greater autonomy, as users can make purchases based on accurate and transparent information.

- **Promotion of Ethical E-commerce Practices**: By raising awareness of dark patterns and other deceptive practices, Hidden Cost Identifier encourages online retailers to adopt fairer, more transparent practices. The project contributes to a shift towards a digital marketplace that prioritizes consumer rights and ethical standards.
- **Unified Shopping Solution**: Unlike standalone tools that address specific aspects of e-commerce, Hidden Cost Identifier integrates multiple functionalities into a single extension, offering users a streamlined experience that encompasses cost transparency, price comparison, and customer support. This approach enhances usability and user engagement, making it easier for consumers to access and benefit from the tool.

5.3 SUGGESTIONS FOR FUTURE WORK

While Hidden Cost Identifier has successfully addressed the initial project objectives, there are several opportunities for further enhancement and development. Suggested areas for future work include:

- **Multilingual Support**: Expanding the detection capabilities to accommodate non-English platforms would allow Hidden Cost Identifier to reach a broader audience and address transparency issues on international e-commerce sites. This could involve training additional language models or incorporating translation services to interpret content effectively across different languages.

- **Enhanced Algorithms**: As new dark patterns continue to emerge, refining the detection algorithms to adapt to these evolving tactics will be essential. Future iterations of the project could implement reinforcement learning or continual learning models to improve the Bert model's adaptability. Additionally, expanding the training dataset with newer examples of dark patterns will ensure that the tool remains relevant and effective.

- **In-Depth Price Comparison Capabilities**: Adding more advanced comparison features, such as price history tracking or dynamic notifications for price drops, could further enhance the Price Comparison Functionality. These features would enable users to make

even more cost-effective purchases by tracking trends and receiving alerts for significant price changes over time.

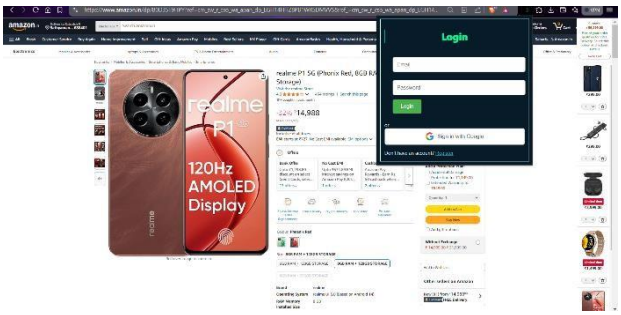
- **User Interface Customization**: Allowing users to personalize the extension's interface, such as enabling or disabling specific features, adjusting alert frequency, and customizing the chatbot's tone, could improve the user experience. These enhancements would make Hidden Cost Identifier even more adaptable to individual preferences and shopping habits.

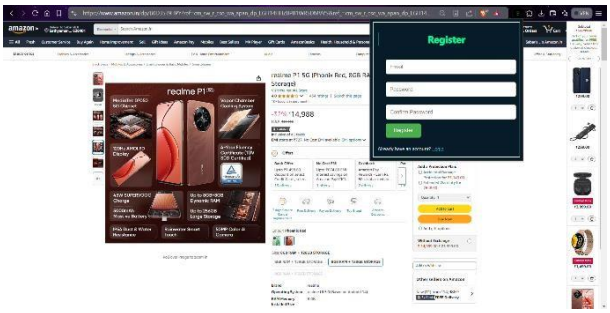
- **Integration with Additional Browsers**: Expanding compatibility to other browsers beyond Chrome, such as Firefox or Safari, would broaden extension's accessibility and allow a larger user base to benefit from its features.

- **Expanded Data Analytics and Reporting**: Integrating an analytics dashboard to provide insights on spending patterns, common dark patterns encountered, and overall savings from price comparisons could help users better understand their online shopping behaviour. This data could also serve as valuable feedback for improving the tool's accuracy and functionality.

CHAPTER 6
USER INTERFACE

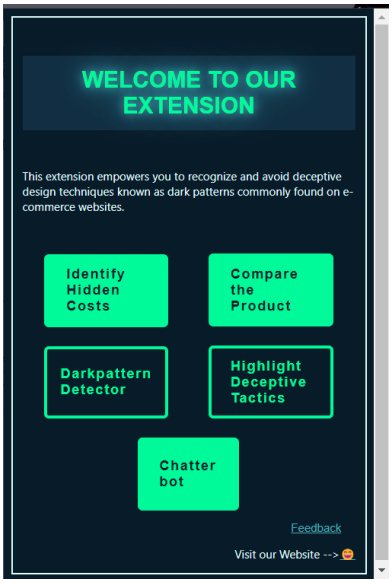
6.1 LOGIN AND REGISTER :





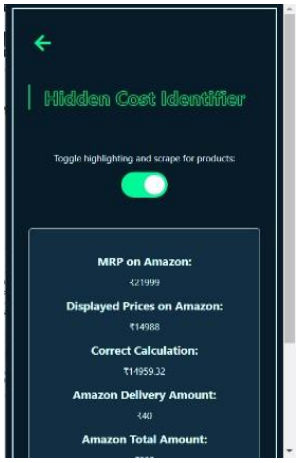
Login Register

6.2 HOME PAGE :

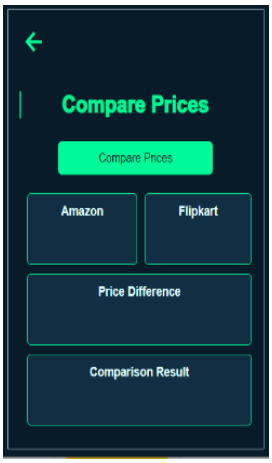


Home Page

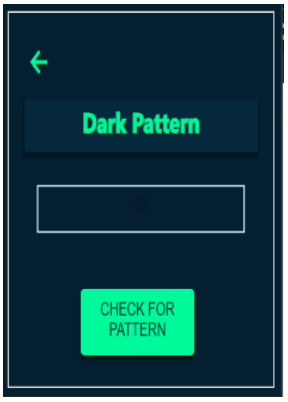
6.3 FEATURES :



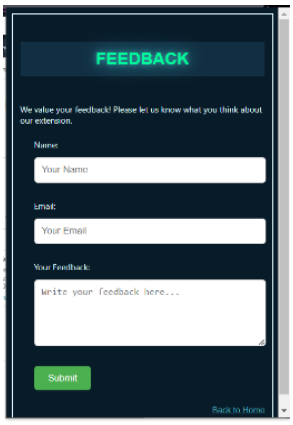
Hidden cost Identifier



Compare Prices



Dark Pattern



Feedback

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