

**Manipulative Design Strategies and Deceptive User Interface
Tactics in E-Commerce**

PROJECT REPORT

21AD1513- INNOVATION PRACTICES LAB

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BONAFIDE CERTIFICATE

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ABSTRACT

The growth of e-commerce has enhanced accessibility and convenience, but it has also facilitated the rise of "dark patterns." These deceptive design strategies manipulate users into making choices that primarily benefit service providers, often compromising user autonomy and understanding. Dark patterns manifest through convoluted user flows, including hidden options, complex navigation, and misleading terminology that can lead to unintended actions, such as accidental purchases or subscriptions. Common tactics include deceptive opt-in/opt-out systems that employ ambiguous language, pre-checked boxes for additional services, and unclear subscription terms, capitalizing on user inattention. Visual manipulation is another concern, with elements like fake notifications creating urgency and misleading buttons prompting unintended actions. Additionally, hidden subscription auto-renewals obscure terms and processes, making it challenging for users to manage or cancel subscriptions. This paper examines the impact of dark patterns on key performance metrics like user engagement, conversion rates, and compliance with legal standards. While dark patterns may yield short-term gains in conversion rates, they can erode user trust and satisfaction over time, raising compliance issues. A comprehensive technical analysis is essential to identify, detect, and evaluate dark patterns' effects on user behavior and system performance. By examining e-commerce platforms, analyzing user interactions, and assessing performance metrics, we can better understand the implications of dark patterns and devise strategies to promote a more transparent, user-centric e-commerce experience.

Keywords: Deep Learning, Pattern Recognition, Real-time Processing, Data Analytics

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LIST OF ABBREVIATIONS

ABBREVIATIONS	MEANING
BERT	BIDIRECTIONAL ENCODER REPRESENTATIONS FROM TRANSFORMERS
RoBERTa	ROBUSTLY OPTIMIZED BERT APPROACH
ALBERT	A LITE BERT
XLNet	A GENERALIZED AUTOREGRESSIVE PRETRAINING FOR LANGUAGE UNDERSTANDING
SVM	SUPPORT VECTOR MACHINE
NLP	NATURAL LANGUAGE PROCESSING
AHP	ANALYTIC HIERARCHY PROCESS
ML	MACHINE LEARNING
RF	RANDOM FOREST
GB	GRADIENT BOOSTING

CHAPTER 1

INTRODUCTION

1.1 GENERAL INFORMATION ON DARK PATTERN

Dark patterns in e-commerce are deceptive design strategies used to manipulate customers into making decisions they wouldn't normally choose. These tactics exploit cognitive biases and subtly push users toward actions like unintended purchases, subscriptions, or data sharing. Common dark patterns include sneakily adding items to carts, hiding additional costs until the last step, making it difficult to unsubscribe, or creating false urgency through countdown timers. While these practices can boost short-term profits for businesses, they often erode consumer trust and lead to negative user experiences. Growing awareness and regulatory efforts are now challenging these unethical design methods.

1.2 MAIN PURPOSES OF DARK PATTERNS IN E-COMMERCE

In e-commerce, dark patterns are deliberately crafted to drive profits, collect data, and retain customers by manipulating their behavior. While these tactics can yield short-term gains for businesses, they often come at the cost of customer trust and satisfaction. As awareness of these practices grows, regulatory bodies are working to curtail their use through laws like the European Union's GDPR and California's CCPA, which emphasize transparency and consumer rights. In the long run, businesses that rely heavily on dark patterns risk damaging their reputations and losing customers to more ethical competitors.

1.2.1 INCREASING SALES AND REVENUE

One of the primary purposes of dark patterns is to encourage users to spend more than they initially intended through subtle and deceptive techniques. For instance, some platforms sneakily add products to the cart by pre-selecting add-ons, such as warranties or accessories, which users must manually remove. Additionally, extra fees, like shipping and taxes, are often hidden until the final checkout step, making users feel committed to their purchase. Bait-and-switch tactics further manipulate users by presenting discounted items in search results, only for the true price to be revealed at checkout. These strategies leverage “commitment bias,” making users more likely to complete their purchases.

1.2.2 BOOSTING SUBSCRIPTIONS AND ENGAGEMENT

Dark patterns are frequently employed to trick users into signing up for subscriptions, ensuring recurring revenue for businesses. One common tactic is the “roach motel” design, where it's easy to enroll but challenging to cancel due to hidden unsubscribe links or complex processes. Auto-renewal traps catch users off guard, leading them to be automatically charged after a free trial without clear reminders. Additionally, many platforms set subscription-based services as the default option, requiring users to actively opt-out to avoid ongoing charges. These strategies exploit user inertia, knowing that most people won't put in the effort to cancel.

1.2.3 HARVESTING PERSONAL DATA

Many e-commerce platforms leverage dark patterns to collect user data for targeted advertising and business opportunities without users fully realizing it. One common tactic involves pre-checked consent boxes that allow companies to gather personal information or send promotional emails, assuming most users won't uncheck them. Additionally, some sites require forced registration, compelling users to create an account or provide unnecessary personal information before completing a purchase. Misleading opt-outs are also prevalent, as options to decline data sharing or newsletters are often hidden or confusing, ensuring businesses gain valuable insights for future marketing campaigns.

1.2.4 CREATING A SENSE OF URGENCY OR SCARCITY

Dark patterns exploit fear of missing out (FOMO) by creating a sense of urgency or scarcity that compels users to act quickly. Websites often use countdown timers, displaying ticking clocks to pressure users into making immediate purchases, even when deals aren't time-sensitive. Limited stock notices, such as "Only 2 left in stock!", foster a false sense of urgency, urging users to buy right away. Additionally, flash sales or limited-time offers push consumers to make hasty decisions, as they fear losing out on opportunities. These tactics manipulate emotional decision-making, leading to impulsive actions.

1.3 TYPES OF DARK PATTERNS FOUND IN E-COMMERCE

Dark patterns exploit cognitive biases and emotional responses to manipulate user decisions, often leading to negative experiences and eroded trust. Tactics like countdown timers and pre-checked consent boxes pressure users into hasty purchases and unwanted subscriptions. As consumers become aware of these

manipulative practices, they increasingly demand transparency and ethical behaviour from e-commerce platforms. This scrutiny encourages businesses to adopt clearer policies regarding data collection and simplify cancellation processes. By prioritizing ethical design, companies can foster customer loyalty and build positive reputations, ultimately benefiting both consumers and businesses in the evolving e-commerce landscape.

1.3.1 SNEAK INTO BASKET

This dark pattern, known as "sneak into basket," involves the automatic addition of items to a user's shopping cart without their explicit consent. For example, when shopping online, customers might find that extra products, such as warranties or accessories, are pre-selected and included in their cart by default. This tactic exploits user inattention, as many shoppers may overlook these additional items while checking out. As a result, users often end up paying for products they didn't intend to purchase, leading to frustration and dissatisfaction with the shopping experience. It cleverly nudges users towards spending more than they planned.

1.3.2 HIDDEN COSTS

This dark pattern, known as "hidden costs," involves revealing additional charges, such as shipping fees, taxes, or handling costs, only at the final stages of the checkout process. By withholding this information until the end, e-commerce platforms create a false sense of security regarding the total price. When users finally see the inflated total, they often feel frustrated or misled, leading to a sense of commitment that can compel them to complete the purchase despite their dissatisfaction. Conversely, this tactic can also result in cart

abandonment if customers are caught off guard by unexpected expenses, harming the retailer's revenue.

1.3.3 ROACH MOTEL

This dark pattern, known as the "roach motel," makes signing up for a service simple while complicating the cancellation process. Users often encounter hidden unsubscribe links or convoluted procedures, leading to frustration and discouragement, effectively trapping them in unwanted subscriptions.

CHAPTER 2

LITERATURE REVIEW

Companies now have to use a variety of strategies to attract and retain customers in the e-commerce market. Some businesses use dark patterns—design signals meant to subtly persuade consumers to make decisions they otherwise would not have—while others use digital nudges to help clients through the purchasing process. The phrase "dark plateresque" describes purposeful and dishonest design choices that &QuoteNet the service employs by taking advantage of psychological strategies to coerce customers into making unanticipated and unpleasant judgments. The effectiveness of dark patterns is influenced by four main factors: motivational, social, cognitive, and technical. Current research explores these areas in great detail. In e-commerce, dark patterns are becoming more and more common. Some companies are employing them to boost revenue and engage customers. [8] Designers usually ignore the whole user experience in favor of maximizing the "happy path" in order to meet shareholder goals because to time constraints and resource restrictions. Moreover, a few scholars argue that the prevalence of dark patterns can be attributed to a lack of ethical instruction in design methods. [6] This review of the literature aims to shed light on the characteristics of dark patterns and the reasons behind their use in e-commerce. It also looks at the reasons e-commerce companies should steer clear of these kinds of products and makes recommendations. E-commerce businesses use dark patterns, or deceptive design elements, to control user behavior for their own gain. Even though these patterns are frequently employed to boost revenues, they could have a negative effect on customers. This study assesses and rates several dark

patterns to identify which are most lucrative and risky. The study uses the Analytic Hierarchy Process (AHP) to rank the different sorts of dark patterns based on data that has already been published. Dark commercial practices are causing people to worry since they have the potential to gravely harm consumers, leading to financial losses, emotional distress, and a deterioration in their trust in businesses. Among the fifteen e-commerce sites assessed were About You, Aliexpress, Allylikes, Amazon, Asos, Bonprix, Galaxus, Globus, H&M, LaRedoute, Manor, Wish, Zalando, and Zara. Dark patterns were found to be most prevalent on Shein, an ultra-fast fashion retailer, followed by Aliexpress, Amazon, and La Redoute. Dark patterns have the ability to impair consumers' ability to manage and secure their personal data. As long as accounts are active, businesses can keep creating unique profiles for targeted advertising and analysis.

2.1 Prioritizing dark patterns in the e-commerce industry – an empirical investigation using analytic hierarchy process

This study investigates how dark patterns are prioritized in the e-commerce industry through the Analytic Hierarchy Process (AHP). It aims to categorize different dark patterns, assess their effects on user experience, and highlight the ethical implications for businesses. The findings reveal a hierarchy of dark patterns based on their prevalence and impact, providing insights for stakeholders aiming to improve user-centric design.

The authors conducted a survey involving e-commerce users and industry experts to gather qualitative and quantitative data. They identified key criteria for evaluating dark patterns, such as user deception, frequency of use, and the potential for harm. Using AHP, they calculated priority scores for each dark

pattern, allowing for a structured analysis of their relative importance in the e-commerce context.

AUTHOR : [1] Singh, V., Vishvakarma, N.K., Mal, H., & Kumar, V.

YEAR : 2024

2.2 Dark patterns in e-commerce: A systematic review and future research directions

This systematic review synthesizes existing literature on dark patterns in e-commerce, examining their types, prevalence, and impacts on consumer behavior. The study identifies research gaps, such as the lack of longitudinal studies, and offers future research directions to enhance understanding of dark patterns and their regulatory implications.

The authors conducted a comprehensive literature review, systematically searching databases for relevant studies published on dark patterns. They utilized a coding scheme to categorize findings and synthesized the results to highlight themes and gaps. The review culminated in a framework for future research, emphasizing the need for empirical studies and practical applications in regulatory contexts.

AUTHOR : Sin, E., Kim, H., & Lee, Y. (2022)

YEAR : 2022

2.3 Dark patterns at scale: Findings from a crawl of 11K shopping websites

This paper presents a large-scale analysis of dark patterns found on 11,000 shopping websites. The study identifies prevalent dark patterns and assesses their implications for user experience and ethical design practices in e-commerce.

The researchers employed automated web crawling techniques to collect data from a diverse array of e-commerce sites. They utilized content analysis to categorize and quantify the dark patterns identified during the crawl. The analysis included statistical methods to assess the frequency of each pattern and its correlation with user engagement metrics, ultimately drawing conclusions about their ethical implications.

AUTHOR : Mathur, A., Narayanan, A., & Chetty, M. (n.d.).

YEAR : 2024

2.4 Sludge: What Stops Us from Getting Things Done and What to Do About It

In this book, the author explores the concept of "sludge," which refers to obstacles that hinder effective decision-making, including the use of dark patterns in e-commerce. Sunstein discusses the psychological impacts of these practices and suggests ways to counteract their negative effects on consumer autonomy and well-being.

The analysis draws on behavioral economics and cognitive psychology, using case studies and theoretical frameworks to explore the effects of sludge on consumer choices. The author synthesizes insights from various disciplines to

develop practical recommendations for policymakers and businesses aimed at reducing the prevalence of dark patterns.

AUTHOR : Sunstein, C.R. (2020)

YEAR : 2020

2.5 Dark patterns in e-commerce: A review and future directions

This review focuses on dark patterns in e-commerce, analyzing their implications for consumer behavior, business practices, and regulatory responses. It emphasizes the ethical considerations surrounding dark patterns and suggests areas for future research.

The authors conducted a systematic literature review, compiling studies on dark patterns across various e-commerce platforms. They used thematic analysis to identify key trends, patterns, and gaps in the existing literature. The review also involved critical evaluation of regulatory frameworks, leading to recommendations for improving transparency and user protection

AUTHOR: Kumar, A., & Maheshwari, B.

YEAR : 2022

2.6 Understanding dark patterns in e-commerce: A conceptual framework

This paper proposes a conceptual framework for understanding dark patterns in e-commerce, categorizing them based on their design intentions and

effects on consumer behavior. It aims to provide a structured approach for analyzing dark patterns and their implications for user experience.

The authors employed a qualitative approach, reviewing existing literature on design ethics and consumer behavior. They synthesized insights to develop a framework that categorizes dark patterns, highlighting motivations behind their use. The study also discusses potential impacts on user trust and the need for ethical design practices.

AUTHOR: Luo, X., & Li, M.

YEAR : 2022

2.7 Dark patterns in e-commerce: An empirical study of online shopping websites

This empirical study investigates dark patterns across online shopping websites, assessing their prevalence and ethical implications. The authors explore consumer awareness and reactions to these practices, emphasizing the need for increased regulation and user education.

A comprehensive content analysis was conducted on a sample of online shopping websites to identify dark patterns. The researchers complemented this analysis with user surveys and interviews to gather qualitative data on consumer experiences. Statistical methods were used to analyze correlations between exposure to dark patterns and user trust, satisfaction, and purchase behavior.

AUTHOR : Bösch, C., Ersoy, G., & Leicht, N. (2022).

YEAR : 2022

2.8 Dark patterns in e-commerce: A survey of online shopping websites

This survey examines the presence of dark patterns in e-commerce, focusing on their impact on consumer trust and satisfaction. The study highlights the ethical challenges posed by these practices and calls for more robust regulatory frameworks.

The researchers developed and distributed a survey to online shoppers, collecting data on their experiences with dark patterns. They utilized quantitative analysis to assess the relationship between exposure to dark patterns and measures of trust and satisfaction. The findings were statistically analyzed to draw conclusions about the broader implications of dark patterns in e-commerce.

AUTHOR : Hoffmann, C., & Wilke, T.

YEAR :2022

No.	Paper Title	Authors & years	Findings	Advantages	Disadvantages
1.	"Prioritizing dark patterns in the e-commerce industry – an empirical investigation using analytic hierarchy process"	Singh, V., Vishvakarma, N.K., Mal, H., & Kumar, V. 2024	Empirical investigation prioritizing dark patterns in e-commerce using an analytic hierarchy process.	Offers structured prioritization, helping businesses understand which dark patterns are most harmful.	May be limited to specific e-commerce contexts; complex methodology might limit accessibility for practitioners.
2.	"Dark patterns in e-commerce: A systematic review and future research directions"	Sin, E., Kim, H., & Lee, Y. 2022	Systematic review of dark patterns in e-commerce with suggestions for future research.	Comprehensive review that synthesizes current knowledge and identifies research gaps.	Primarily theoretical; lacks empirical data and practical applications.
3.	"Dark patterns at scale: Findings from a crawl of 11K"	Mathur, A., Narayanan, A., & Chetty, M.	Large-scale analysis of dark patterns across 11K	Extensive dataset strengthens findings, offering realistic picture	Limited to e-commerce, may not capture dark patterns in

	shopping websites"		e-commerce websites	of dark pattern prevalence.	other industries.
4.	"Sludge: What Stops Us from Getting Things Done and What to Do About It	Sunstein, C.R. 2020	Examines "sludge" in decision-making processes, which obstructs user action and productivity.	Provides actionable insights on reducing sludge, which overlaps with certain types of dark patterns.	Broad focus on "sludge"; not exclusively focused on dark patterns or the digital realm.
5.	"Dark patterns in e-commerce: A review and future directions"	Kumar, A., & Maheshwari, B. 2022	Review of dark patterns in e-commerce, suggesting areas for further exploration	Identifies key research gaps and provides a foundation for future investigations.	Lacks primary data; based on secondary sources and theoretical analysis.
6.	"Understanding dark patterns in e-commerce: A conceptual framework"	Luo, X., & Li, M. 2022	Proposes a conceptual framework to understand dark patterns in e-commerce.	Conceptual framework aids in systematically studying and categorizing dark patterns.	Framework may not account for newer or emerging dark patterns; lacks empirical validation.

7.	Dark patterns in e-commerce: An empirical study of online shopping websites"	Bösch, C., Ersoy, G., & Leicht, N. 2022	Empirical study examining the presence and types of dark patterns across online shopping websites.	Empirical approach with concrete data adds credibility and practical relevance to the findings.	Focuses solely on online shopping websites, limiting the findings' applicability to other platforms.
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Table 2.1: literature survey

CHAPTER 3

SYSTEM DESIGN

3.1 SYSTEM ARCHITECTURE

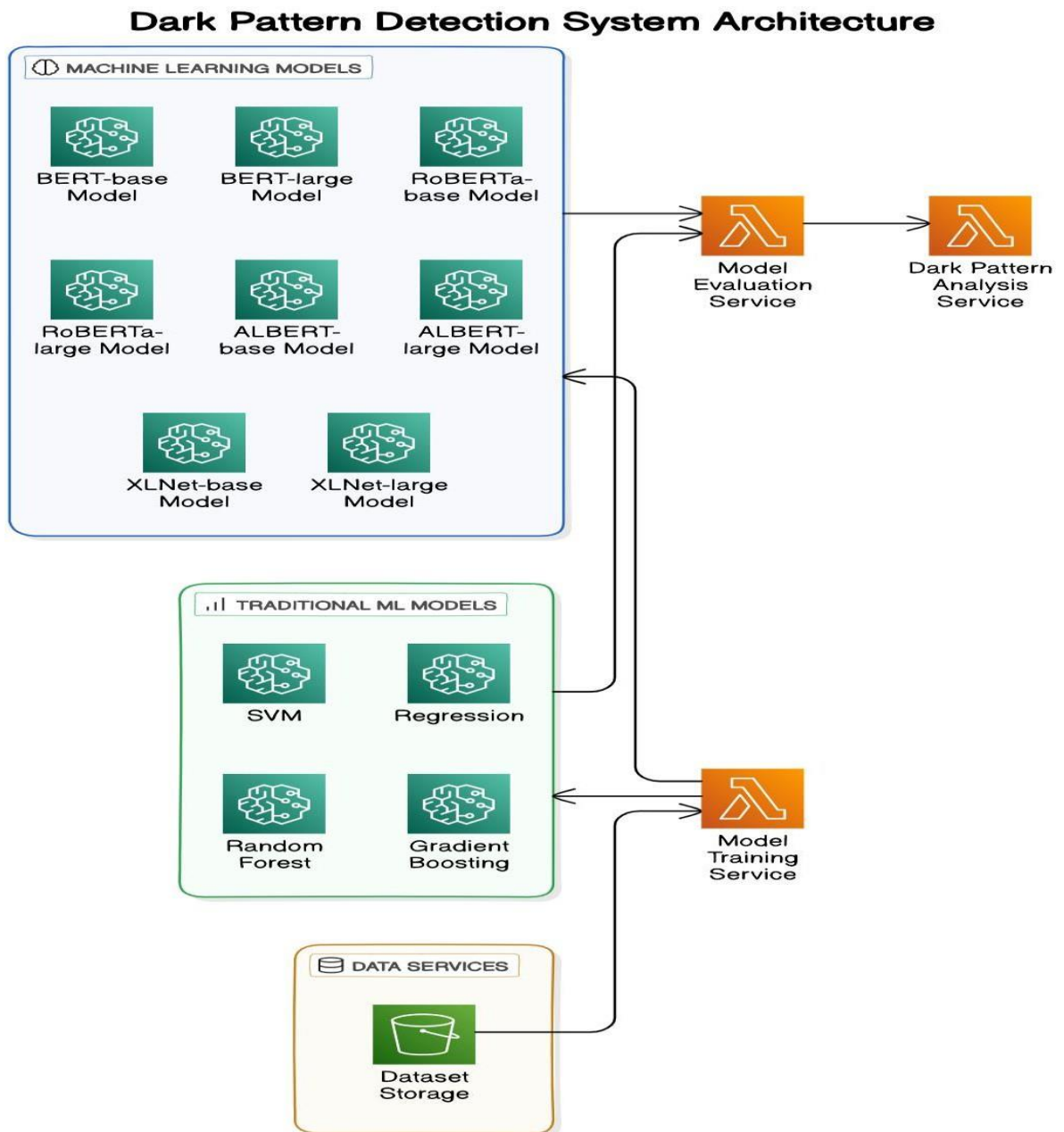


fig 3.1 : system architecture

This architecture diagram illustrates a Dark Pattern Detection System designed for identifying deceptive practices in e-commerce. It consists of several components:

1. **Machine Learning Models:** The system includes various pre-trained NLP models like BERT, RoBERTa, ALBERT, and XLNet, each in "base" and "large" versions, which provide language understanding capabilities for detecting dark patterns.
2. **Traditional ML Models:** It also incorporates traditional machine learning models, such as Support Vector Machine (SVM), Regression, Random Forest, and Gradient Boosting, which contribute additional insights or alternative methods for classification.
3. **Data Services:** Dataset Storage stores the labeled data used for training and evaluating models.
4. **Model Training Service:** This service processes data from Dataset Storage, training both NLP and traditional models.
5. **Model Evaluation Service:** Evaluates model accuracy and effectiveness.
6. **Dark Pattern Analysis Service:** Analyzes detected patterns, offering insights on the types and severity of dark patterns identified.

This layered approach enables robust and versatile detection of e-commerce dark patterns.

3.2 FLOW DIAGRAM

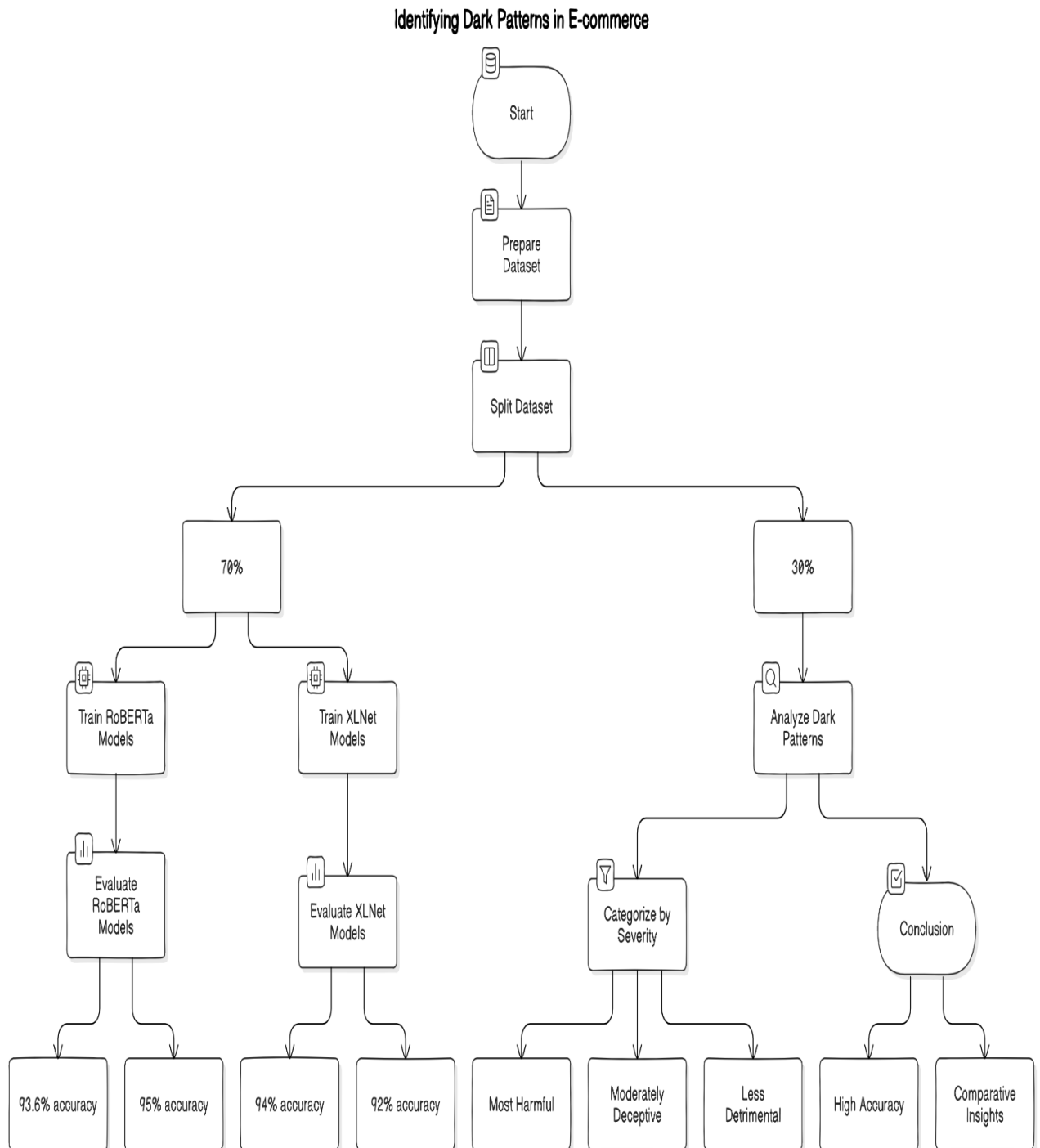


Fig 3.2: Flow Chart of the Proposed System

This flowchart outlines a structured approach to identifying and categorizing dark patterns in e-commerce using machine learning and data analysis.

1. **Start:** The process begins with initializing the project to identify dark patterns in e-commerce platforms.
2. **Prepare Dataset:** Data is gathered and cleaned to ensure it's ready for analysis and training, making it suitable for identifying dark patterns.
3. **Split Dataset:** The dataset is split into two parts:
 - 70% for model training and evaluation.
 - 30% for further analysis of dark patterns.
4. **70% Model Training and Evaluation:**
 - Train RoBERTa Models: RoBERTa, a transformer-based NLP model, is trained to recognize patterns in the data.
 - Evaluate RoBERTa Models: The trained RoBERTa models are evaluated for performance, achieving accuracies of 93.6% and 95%.
 - Train XLNet Models: Similarly, XLNet models, known for their bidirectional training approach, are also trained on the dataset.

- Evaluate XLNet Models: XLNet models are evaluated, with accuracies of 94% and 92%.

5. 30% Dark Pattern Analysis:

- Analyze Dark Patterns: The 30% data is analyzed for dark patterns, aiming to understand the nature of deceptive techniques used.
- Categorize by Severity: The identified dark patterns are classified by severity into:
 - Most Harmful: Likely the most deceptive or damaging to consumers.
 - Moderately Deceptive: Patterns that may mislead but with less impact.
 - Less Detrimental: Deceptive techniques that may be less severe or harmful.

6. Conclusion:

- Summarizes the results, noting the high accuracy achieved by both RoBERTa and XLNet models.
- Provides Comparative Insights, analyzing differences between the models and giving a deeper understanding of dark patterns by severity, potentially offering insights for regulatory actions or e-commerce best practices.

CHAPTER 4

PROJECT MODULES

The project consists of Five modules. They are as follows,

1. Data Collection and Preparation
2. Transformer-based NLP Models
3. Traditional Machine Learning Models
4. Model Training, Evaluation, and Categorization
5. Analysis of Dark Patterns and Ethical Insights

4.1 Data Collection and Preparation

A dataset of 3,000 text samples—including product descriptions, customer reviews, terms and conditions, and promotional materials from e-commerce platforms—is compiled. This diverse dataset enables the model to detect a variety of dark patterns. It is split into training (70%), validation (15%), and test (15%) sets to facilitate systematic model training, tuning, and performance evaluation

.

4.2 Transformer-based NLP Models

Transformer-based models, including BERT, RoBERTa, ALBERT, and XLNet, are employed to detect subtle and complex dark patterns in text. BERT-base and BERT-large serve as foundational models, with the latter achieving higher accuracy (93%). RoBERTa models demonstrate improved accuracy due

to optimized training (RoBERTa-large achieves 95%). ALBERT balances efficiency and performance, while XLNet's permutation-based training captures nuanced context, with XLNet-large reaching 94% accuracy.

4.3 Traditional Machine Learning Models

Traditional models, such as Support Vector Machine (SVM), Regression, Random Forest, and Gradient Boosting, are included as baseline comparisons. Random Forest and Gradient Boosting, with their ensemble learning techniques, perform better than SVM and Regression, though they fall short of transformer models. This module highlights the added value of advanced NLP models over traditional approaches in detecting dark patterns.

4.4 Model Training, Evaluation, and Categorization

The models undergo training and evaluation via a dedicated service, allowing assessment of accuracy on validation and test sets. Dark patterns identified by the models are then categorized by severity: Most Harmful (Red), Moderately Deceptive (Yellow), and Less Detrimental (Green). This color-coded system, inspired by Singh et al., aids in prioritizing patterns based on their potential harm to users.

4.5 Analysis of Dark Patterns and Ethical Insights

Insights from recent studies, including Sunstein's concept of "sludge," are incorporated to emphasize ethical considerations. "Sludge" refers to barriers that hinder user decisions and often contribute to dark patterns. This module

underlines the importance of transparency in e-commerce design, advocating for user-friendly, non-manipulative interfaces. The results validate that transformer models, especially RoBERTa-large, are well-suited for accurately identifying dark patterns, supporting future research and ethical guidelines.

CHAPTER 5

SYSTEM REQUIREMENTS

5.1 INTRODUCTION

This chapter involves the technology used, the hardware requirements and the software requirements for the project .

5.2 REQUIREMENTS

5.2.1 Hardware Requirements

- Hard disk : 500 GB and above
- Ram : 4GB and above
- Processor : I-5 and above

5.2.2 Software Requirements

- Windows 10 and above
- Jupyter Notebook
- Kaggle-dataset

5.3 Technology Used

- I. Python 3.10+**
- II. IDLE**

5.3.1 Software description

5.3.1.1 PYTHON

Python was created by Guido van Rossum and first released in 1991, born out of his desire to address the limitations of the ABC programming language. Van Rossum envisioned a language that combined simplicity and power, emphasizing readability to make programming accessible to a broader audience. Over the years, Python has evolved into a versatile language widely used across various domains, including web development, data analysis, artificial intelligence, automation, and scientific computing. Its clear and concise syntax, which closely resembles natural language, makes it particularly appealing to beginners while still offering robust features for experienced developers. Python supports multiple programming paradigms, including procedural, object-oriented, and functional programming, allowing flexibility in coding styles. With dynamic typing, extensive libraries like Pandas, NumPy, and TensorFlow, and a rich ecosystem bolstered by a vibrant community, Python enables developers to tackle complex tasks with minimal code. Its cross-platform compatibility further enhances its accessibility, making Python one of the most popular and enduring programming languages in the world today, widely adopted in educational institutions, startups, and large enterprises alike.

5.3.1.2 Platform

The Python platform is a suite of tools and libraries that facilitate developing and running programs written in the Python programming language. A Python platform typically includes an interpreter, libraries, and package management tools; it may also involve additional frameworks and virtual environments

depending on the project requirements. Python is platform-independent, meaning it can run on various operating systems such as Windows, Linux, and macOS without modification. Python's versatility makes it suitable for different types of applications and devices: it can be used in microcontrollers through MicroPython, which enables Python programs to run on IoT hardware; for web development through frameworks like Django or Flask to build scalable web applications; for data science with libraries such as Pandas, NumPy, and Matplotlib; and for automation or scripting in system administration and testing tasks. Python's platform consists of several components, each contributing to its functionality. For example, the Python Interpreter executes Python code line by line, as Python is an interpreted language. Libraries and packages are managed using tools like Pip and virtual environments (venv) to ensure dependencies are handled properly and projects are isolated to prevent conflicts. Python is the default implementation of Python that compiles Python code to bytecode and runs it using a virtual machine (Python Virtual Machine or PVM). Some implementations, such as PyPy, include Just-in-Time (JIT) compilation to optimize performance by converting Python bytecode into native machine code during runtime.

The platform's essential components include the compiler, the runtime environment, and an extensive standard library. The Python Compiler (like PyPy) transforms code into bytecode for efficient execution. The runtime environment, powered by the PVM, executes the bytecode and ensures that Python code runs consistently across different platforms. Python's standard libraries provide ready-made modules for functionalities like file handling, networking, and data processing. Similar to Java, the Python ecosystem offers

flexibility to develop anything from simple scripts to large-scale applications, leveraging its extensive libraries and frameworks.

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5.3.1.3 JUPYTER NOTEBOOK

Jupyter Notebook is an open-source web application that allows users to create and share documents containing live code, equations, visualizations, and narrative text. Primarily used with Python, it supports various programming languages through different kernels, making it versatile for data analysis, scientific computing, and machine learning tasks. Users can write and execute code in real-time, enabling interactive exploration of data. The integration of Markdown allows for formatted text, making it easy to document code and results effectively. Rich outputs such as plots and interactive visualizations can be produced using libraries like Matplotlib and Seaborn. Jupyter Notebooks facilitate collaboration by being easily shareable and exportable in multiple formats, promoting reproducibility in research. Installation can be done via Anaconda or pip, and launching the application opens a user-friendly web interface for managing notebooks. This combination of features makes Jupyter Notebook a favored tool among data scientists, educators, and researchers.

5.3.2 KAGGLE DATASET

Kaggle is a popular platform that hosts a vast collection of datasets across various domains, making it an invaluable resource for data scientists and machine learning practitioners. Users can access datasets on topics such as healthcare, finance, sports, and social media, among others. Each dataset typically includes metadata, descriptions, and examples of how to use it,

facilitating a better understanding of the data. Kaggle also offers features like data visualization tools, competitions, and collaborative notebooks, allowing users to experiment and share their findings with the community. Additionally, users can contribute their datasets, fostering an environment of knowledge sharing and collaboration. This accessibility and community engagement make Kaggle an essential platform for learning and developing data-driven projects.

CHAPTER 6

CONCLUDING REMARKS

6.1 CONCLUSION

This research highlights the significant impact that dark patterns—deceptive design tactics commonly used in e-commerce—have on user trust and decision-making capabilities. Dark patterns manipulate users into making choices that may not align with their best interests, ultimately undermining their autonomy and satisfaction. The study employed advanced natural language processing (NLP) models, including BERT, RoBERTa, ALBERT, and XLNet, to detect and classify these dark patterns with remarkable accuracy. Notably, the RoBERTa-large model achieved an impressive accuracy of 95%, while the XLNet-large model followed closely with 94%. These results underscore the models' effectiveness in identifying even subtle dark patterns, which can be particularly challenging to detect given their often nuanced and misleading nature. Furthermore, the findings reveal a critical tension in e-commerce: while dark patterns may lead to increased conversion rates and favorable short-term performance metrics—such as higher sales and sign-up rates—they simultaneously jeopardize user trust. The research emphasizes the importance of leveraging artificial intelligence not just for detecting dark patterns but also for promoting ethical design practices. By using AI to identify and counteract these dishonest strategies, stakeholders—including e-commerce platforms, designers, and marketers—can foster a more transparent and user-centric online environment. Ultimately, the study advocates for a shift in focus towards user safety and ethical design, suggesting that prioritizing these values can enhance

the overall viability and integrity of the e-commerce industry. By building trust through transparency and ethical practices, businesses can cultivate long-term relationships with their customers, ultimately benefiting both users and service providers alike.

REFERENCES

- [1] Singh, V., Vishvakarma, N.K., Mal, H., & Kumar, V. (2024). Prioritizing dark patterns in the e-commerce
- [2] industry – an empirical investigation using analytic hierarchy process. *Measuring Business Excellence*, 28(2), 177-192. doi: 10.1108/MBE-08-2023-0114
- [3] Sin, E., Kim, H., & Lee, Y. (2022). Dark patterns in e-commerce: A systematic review and future research directions. *Journal of Business Research*, 147, 383-395.
- [4] Mathur, A., Narayanan, A., & Chetty, M. (n.d.). Dark patterns at scale: Findings from a crawl of 11K shopping websites. *Proceedings of the ACM on Human-Computer Interaction*, 4(CSCW1), 1-27.
- [5] Kumar, A., & Maheshwari, B. (2022). Dark patterns in e-commerce: A review and future directions. *International Journal of Electronic Commerce Studies*, 13(1), 1-22.
- [6] Luo, X., & Li, M. (2022). Understanding dark patterns in e-commerce: A conceptual framework. *Journal of Retailing and Consumer Services*, 66, 102933.
- [7] Bösch, C., Ersoy, G., & Leicht, N. (2022). Dark patterns in e-commerce: An empirical study of online shopping websites. *Journal of Business Ethics*, 177(2), 257-275.
- [8] Hoffmann, C., & Wilke, T. (2022). Dark patterns in e-commerce: A survey of online shopping websites. *Journal of Retail*
- [9] Sunstein, C.R. (2020). *Sludge: What Stops Us from Getting Things Done and What to Do About It*. Farrar, Straus and Giroux.

