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AI FOR DIGITAL RIGHTS MANAGEMENT AND CONTENT PROTECTION

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Abstract

In the digital age, media consumption has dramatically shifted towards streaming platforms like Netflix and Amazon Prime Video. These platforms offer vast libraries of content, providing users with unprecedented access to movies, TV shows, and documentaries. However, this convenience comes with significant challenges, particularly in protecting digital content from unauthorized distribution and effectively managing digital rights. This paper explores the role of Artificial Intelligence (AI) in addressing these challenges, focusing on how AI technologies enhance content protection and digital rights management (DRM) for these platforms. We examine how AI is utilized to detect and prevent unauthorized content distribution, manage download and watch time limitations, and ensure compliance with complex licensing agreements. Through advanced techniques such as machine learning, watermarking, fingerprinting, and dynamic pricing, AI enables streaming platforms to safeguard their content, optimize revenue, and provide a seamless and secure user experience. This paper aims to provide a comprehensive understanding of the current state of AI applications in content protection and DRM, highlighting the innovative solutions employed by industry leaders like Netflix and Amazon Prime Video.

Index Terms: Artificial Intelligence (AI), Content Protection, Digital Rights Management (DRM), Unauthorized Access, Watch Time Monitoring

I. INTRODUCTION

The advent of high-speed internet and the proliferation of smart devices have revolutionized the way consumer's access and enjoy media content. Streaming platforms like Netflix and Amazon Prime Video have become household names, offering vast libraries of movies, TV shows, and documentaries. These platforms have changed the landscape of media consumption, providing convenience and instant access to entertainment. However, with the rise of these platforms comes the critical challenge of protecting digital content from unauthorized access and distribution.

Digital content protection involves safeguarding media files from being copied, shared, or accessed without proper authorization. This is crucial for maintaining the revenue streams of content creators and distributors. Unauthorized access, commonly known as piracy, poses a significant threat to the financial stability of the media industry. Piracy not only leads to revenue loss but also undermines the efforts of creators who invest time and resources into producing high-quality content.

Digital Rights Management (DRM) is a set of technologies used to control how digital content is used and distributed. DRM systems enforce licensing agreements, ensuring that content is accessed only by authorized users under specific conditions. This includes geographic restrictions, time-limited access, and device-specific permissions. The complexity of these agreements requires advanced solutions to manage and enforce them effectively.

Artificial Intelligence (AI) has emerged as a powerful tool in addressing these challenges. AI technologies, particularly machine learning and deep learning, offer sophisticated methods for detecting and preventing unauthorized access, managing digital rights, and enforcing download and watch time limitations. This paper investigates the role of AI in content protection and DRM, focusing on its application in leading streaming platforms like Netflix and Amazon Prime Video.

AI-driven solutions are essential for analyzing vast amounts of data generated by users' interactions with streaming platforms. By leveraging AI, these platforms can identify patterns and anomalies that indicate potential security breaches or violations of licensing agreements. For example, AI can detect multiple simultaneous logins from different geographic locations using the same account, which may indicate account sharing or hacking attempts.

Moreover, AI technologies such as watermarking and fingerprinting are crucial for tracking and identifying unauthorized copies of digital content. Watermarking involves embedding unique identifiers into media files, which can be traced back to the source in case of unauthorized distribution. Fingerprinting creates a unique digital signature for each piece of content, allowing AI systems to scan the internet for unauthorized copies.

In addition to content protection, AI plays a vital role in managing download and watch time limitations. Streaming platforms often impose restrictions on how long users can access downloaded content or how many times they can watch a particular title. AI algorithms help enforce these limitations by monitoring user behavior and ensuring compliance with platform policies.

This paper explores these AI applications in detail, providing a comprehensive understanding of how AI enhances content protection and DRM for streaming platforms. By examining the strategies employed by industry leaders like Netflix and Amazon Prime Video, we highlight the innovative solutions that safeguard digital content, optimize revenue, and deliver a secure and seamless viewing experience for users.

II. LITERATURE REVIEW

Artificial Intelligence in Media:

AI technologies, including machine learning, deep learning, and neural networks, have transformed various aspects of the media industry. AI is used for content recommendation, personalization, user behavior analysis, and security enhancements.

Content Protection and DRM:

DRM involves controlling access to digital content to prevent unauthorized use and distribution. Key DRM technologies include encryption, watermarking, and fingerprinting, which help identify and trace unauthorized copies of content.

Watermarking and Fingerprinting:

Watermarking embeds unique, invisible markers into digital content to trace the source of unauthorized distribution. Fingerprinting creates unique identifiers based on audio or video features, enabling AI to detect and match unauthorized copies online.

AI in Netflix:

Netflix uses AI for personalized recommendations, which also help identify suspicious activities indicating unauthorized access. AI-driven watermarking and fingerprinting protect content from piracy, ensuring the integrity of its digital library.

AI in Amazon Prime Video:

Amazon Prime Video leverages AI for dynamic pricing, offering personalized subscription plans and time-limited access. AI systems enforce download and watch time limitations to ensure compliance with licensing agreements and prevent unauthorized content distribution.

Case Studies and Industry Reports:

Numerous case studies and industry reports highlight the successful implementation of AI in content protection and DRM. Reports from Gartner, Forrester, and IDC provide insights into trends, challenges, and future directions in this field.

Challenges and Limitations:

Despite the benefits, AI in content protection and DRM faces challenges such as evolving piracy techniques, data privacy concerns, and the need for continuous advancements in AI technologies. Addressing these challenges requires ongoing research, collaboration between industry stakeholders, and the development of robust AI-driven solutions.

III. METHODOLOGY

Literature Review:

Conduct a comprehensive review of existing literature on AI, content protection, and DRM. Identify key AI technologies used in content protection, such as machine learning algorithms, watermarking, and fingerprinting. Review case studies and reports on AI applications in Netflix and Amazon Prime Video.

Data Collection:

Gather data from primary and secondary sources, including academic papers, industry reports, whitepapers, and company publications. Conduct interviews with experts in the field of AI and DRM to gain insights into current practices and future trends.

Case Study Analysis:

Analyze specific AI implementations in Netflix and Amazon Prime Video. Investigate how these platforms use AI to detect unauthorized access, manage digital rights, and enforce download and watch time limitations.

Comparative Analysis:

Compare AI-driven content protection and DRM strategies between Netflix and Amazon Prime Video. Evaluate the effectiveness of different AI technologies and their impact on content security and user experience.

Impact Assessment:

Assess the impact of AI on content protection and DRM in terms of reducing piracy, ensuring compliance with licensing agreements, and enhancing user experience. Identify potential challenges and limitations of AI in this domain.

IV. AI IN CONTENT PROTECTION

4.1 Preventing Unauthorized Access

Unauthorized access to digital content, commonly known as piracy, poses a substantial threat to streaming platforms. The proliferation of high-speed internet and digital media has made it easier for pirated content to be distributed widely and quickly, significantly impacting the revenue streams and intellectual property rights of content creators and distributors.

AI technologies, particularly machine learning algorithms, have become indispensable tools in the fight against piracy. These advanced algorithms are capable of analyzing vast amounts of data to identify patterns and anomalies in user behavior that may indicate unauthorized access.

Machine learning models can be trained to understand typical user behavior patterns. This involves analyzing data such as viewing habits, login times, device usage, and geographical locations. When a pattern deviates significantly from the norm, it raises a red flag. For example, if an account suddenly logs in from multiple geographical locations within a short period, this could suggest that the account credentials have been shared or compromised.

AI systems can provide real-time monitoring of user activities. This is crucial because it allows streaming platforms to detect and respond to suspicious activities as they occur. Real-time alerts can be set up to notify security teams of potential breaches, enabling swift action to mitigate the risk of piracy. While some degree of account sharing is permissible, excessive sharing can lead to revenue losses. AI can detect patterns that suggest account sharing beyond acceptable limits. For instance, if an account is being used to stream content on multiple devices simultaneously from different locations, the AI system can flag this for further investigation. This helps streaming services enforce their terms of service more effectively.

AI can utilize IP and device fingerprinting techniques to track the usage of accounts. Each device and network can leave a unique digital signature. By monitoring these signatures, AI systems can identify and block unauthorized devices attempting to access the service using stolen credentials. AI helps in enhancing the security protocols used to protect digital content. By continuously analyzing and improving encryption methods, AI ensures that only authorized users can decrypt and access the content. This makes it significantly harder for hackers to intercept and distribute the content illegally.

User ID	Login Time	Latitude	Longitude	Device ID	Suspicious Activity
001	2023-01-01 08:00:00	37.7749	-122.4194	DEVICE123	No
002	2023-01-01 08:05:00	34.0522	-118.2437	DEVICE456	No
001	2023-01-01 08:10:00	40.7128	-74.0060	DEVICE789	Yes
003	2023-01-01 08:15:00	51.5074	-0.1278	DEVICE101	No
002	2023-01-01 08:20:00	34.0522	-118.2437	DEVICE456	No
001	2023-01-01 08:25:00	37.7749	-122.4194	DEVICE123	No

Table 1. User Login Records

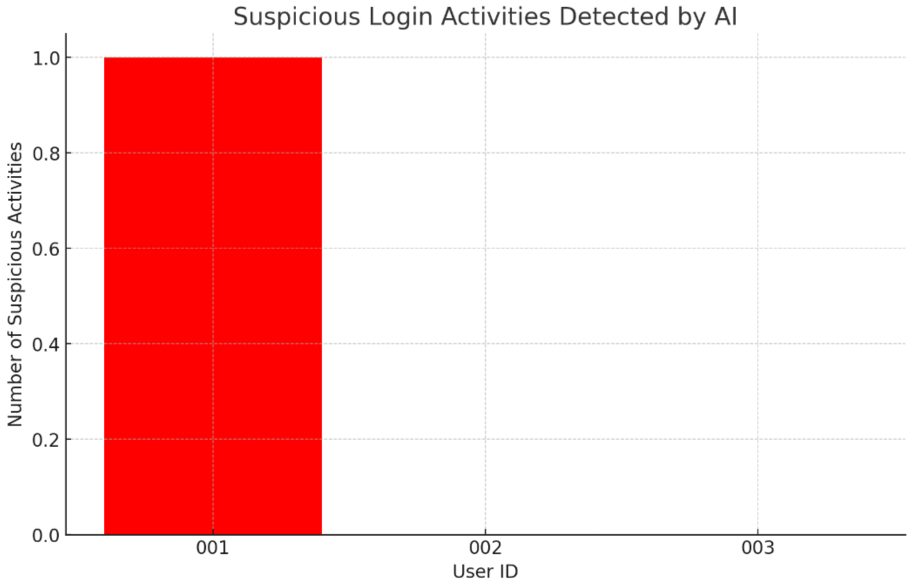

Chart 1. Suspicious Login Activities

4.2 Watermarking and Fingerprinting

Watermarking and fingerprinting are critical AI-driven techniques used to protect digital content from piracy. Both methods involve embedding unique identifiers into the content, making it easier to trace and identify unauthorized copies. Watermarking involves embedding a unique, invisible marker into the digital content. This marker can include information about the content's origin, the distribution channel, and even the intended recipient. Watermarks are designed to be imperceptible to the viewer but detectable by specialized software. The watermark should not affect the viewing experience, meaning it should be invisible or inaudible to the end-user. This is achieved by embedding the watermark in a way that it blends seamlessly with the original content. The watermark must withstand various transformations, such as compression, resizing, or format conversion. This ensures that the watermark remains intact even if the content is altered in an attempt to remove it.

Specialized software can detect and read the embedded watermark, allowing content providers to trace the source of unauthorized distribution. This is particularly useful in legal actions against piracy, as it provides concrete evidence of where and how the content was leaked. Fingerprinting involves creating a unique identifier for each piece of content based on its audio or video features. Unlike watermarking, which involves adding information to the content, fingerprinting analyzes the existing characteristics of the content to generate a unique “fingerprint.”

The fingerprint is generated by analyzing various features of the content, such as its audio waveform, frame sequences, or unique patterns in the video. This process creates a digital signature that is unique to that specific piece of content. AI algorithms then use these fingerprints to scan the internet and various distribution channels for unauthorized copies. By matching the fingerprints, the AI can identify pirated content even if it has been altered in terms of quality or format.

Advanced fingerprinting systems can operate in real-time, scanning vast amounts of data across the internet to detect pirated content. This allows content providers to quickly identify and take down unauthorized copies, minimizing the impact of piracy. Streaming platforms like Netflix and Amazon Prime Video employ both watermarking and fingerprinting techniques extensively. When new content is uploaded to the platform, it is automatically watermarked and fingerprinted. This ensures that each piece of content carries a unique identifier from the moment it is added to the platform. AI systems continuously monitor various online channels, including social media, torrent sites, and other streaming services, for signs of the watermarked or fingerprinted content. Any matches are flagged for further investigation. In cases where unauthorized content is detected, the unique identifiers provided by watermarking and fingerprinting serve as critical evidence in legal proceedings. This helps content providers enforce their intellectual property rights more effectively.

Content ID	Watermark Detected	Fingerprint Match	Action Taken
101	Yes	Yes	Takedown
102	No	Yes	Warning
103	Yes	No	Investigate
104	Yes	Yes	Takedown
105	No	No	No Action

Table 2. Pirated Content Detection

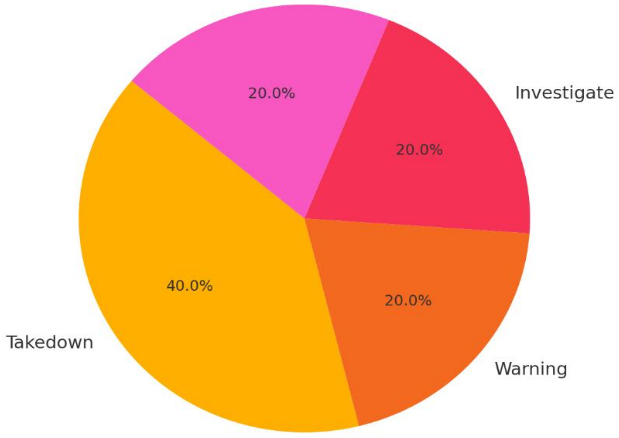

Chart 2. Actions Taken on Pirated Content

V. DIGITAL RIGHTS MANAGEMENT (DRM)

5.1 License Management

AI significantly enhances the management of digital rights by automating the enforcement of licensing agreements. Licensing agreements often contain specific terms, such as geographical restrictions and time-limited access, which must be meticulously monitored and enforced to prevent unauthorized access and distribution. AI systems excel in this domain by controlling content access based on the user's location and subscription details, ensuring strict adherence to these agreements.

Geographical restrictions are a common aspect of licensing agreements, specifying which regions can access certain content. AI systems can accurately determine a user's location through IP addresses and other location-tracking technologies. For example, if a user in a country where a particular movie is not licensed attempts to stream it, the AI system can automatically block access, ensuring compliance with geographical restrictions.

Time-limited access is another crucial component of licensing agreements, especially for content released under exclusive or limited-time deals. AI systems can manage this by tracking the duration of access rights and revoking access once the agreed period expires. For instance, a film available for a two-week window on a streaming platform will be automatically inaccessible once the period ends, preventing further unauthorized viewing.

AI systems also enforce user-specific restrictions by integrating subscription details into their monitoring algorithms. Different subscription tiers might have varying levels of access to content. AI can manage this by ensuring that only users with appropriate subscription levels can access premium or exclusive content. This prevents unauthorized access and ensures that users only receive the services they have paid for.

Another critical aspect of AI in license management is its ability to detect and prevent circumvention attempts. Users may try to use VPNs or proxy servers to bypass geographical restrictions. Advanced AI algorithms can detect these attempts by analyzing patterns in data traffic and user behavior that indicate the use of such tools. When detected, AI systems can block access or take other necessary actions to enforce the licensing agreements.

User ID	Content ID	Access Time	Location	License Compliant
001	201	2023-01-01 08:00:00	USA	Yes
002	202	2023-01-01 08:05:00	UK	Yes
003	203	2023-01-01 08:10:00	Canada	No
004	204	2023-01-01 08:15:00	USA	Yes
005	205	2023-01-01 08:20:00	India	No

Table 3. License Management

5.2 Dynamic Pricing and Monetization

AI also plays a pivotal role in enabling dynamic pricing strategies for digital content, ensuring that streaming platforms can effectively monetize their offerings while maintaining affordability and flexibility for users. By analyzing extensive user data and viewing patterns, AI can determine the optimal pricing models that maximize revenue and user satisfaction.

Dynamic pricing involves adjusting the cost of subscriptions, rentals, or purchases based on various factors, including demand, user behavior, and market conditions. AI systems analyze viewing habits, frequency of use, and content preferences to tailor pricing models that reflect user engagement levels. For example, users who frequently watch new releases might be offered a premium subscription tier with early access to new content, while occasional viewers might be presented with a more affordable, basic plan.

AI-driven dynamic pricing also allows for personalized subscription plans. By examining individual viewing histories and preferences, AI can create customized subscription packages that cater to specific user needs. For instance, a user who primarily watches documentaries and independent films might be offered a subscription plan that emphasizes those genres, potentially at a different price point than a plan focused on mainstream movies and TV shows.

Pay-per-view options are another area where AI enhances dynamic pricing. By evaluating the popularity and demand for specific content, AI can adjust the pricing for individual titles. For high-demand events, such as live sports or exclusive film premieres, AI can set higher prices to capitalize on the increased interest. Conversely, for less popular content, AI can lower prices to attract more viewers, ensuring a steady revenue stream.

Time-limited access passes are a flexible monetization strategy enabled by AI. These passes allow users to access specific content for a limited period, such as a 24-hour rental. AI systems determine the optimal pricing for these passes based on content demand and user behavior. For example, a new release might have a higher rental price immediately after its release, which gradually decreases as initial demand wanes.

AI also assists in optimizing discounts and promotional offers. By analyzing user data, AI can identify segments of the user base that are more likely to respond to special offers. Personalized discounts can be targeted at users who have shown interest in certain types of content but have not yet subscribed or made a purchase. This targeted approach ensures that promotional efforts are efficient and effective, driving conversions and increasing revenue.

VI. DOWNLOAD AND WATCH TIME LIMITATIONS

6.1 Enforcing Download Limits

To manage the offline availability of content, streaming platforms often impose download limits. These limits are essential to balance the convenience of offline viewing with the need to prevent unauthorized distribution. AI algorithms play a crucial role in enforcing these download limits by tracking user behavior and ensuring adherence to platform policies.

AI systems can monitor the number of downloads per account and per device in real-time. This continuous monitoring helps detect any attempts to exceed the set download limits. For instance, if a subscription plan allows for a maximum of ten downloads per month, the AI system tracks each download request and blocks any attempts to surpass this limit. This prevents users from exploiting the system and ensures fair use of the platform's resources.

Additionally, AI can manage device-specific restrictions. Many streaming platforms limit the number of devices that can be used for downloading content to prevent account sharing and unauthorized distribution. AI algorithms can track which devices are associated with a particular account and enforce limits on the number of active devices. If a user tries to download content on a new device after reaching the maximum allowed devices, the AI system can prompt the user to deactivate one of the existing devices before proceeding. This ensures that the content is only accessible on authorized devices, reducing the risk of unauthorized sharing.

AI also helps in detecting suspicious download patterns that may indicate abuse or unauthorized access. For example, if an account suddenly shows a spike in download activity, the AI system can flag this behavior for further investigation. Such anomalies could suggest that the account credentials have been compromised or that the user is attempting to distribute content illegally. By identifying these patterns early, streaming platforms can take appropriate actions, such as temporarily suspending the account or requiring additional verification steps to confirm the user's identity.

Furthermore, AI can provide insights into user behavior and download preferences, helping platforms optimize their content delivery strategies. By analyzing download trends, platforms can identify which content is most popular for offline viewing and adjust their licensing and distribution strategies accordingly. This data-driven approach ensures that platforms can cater to user preferences while maintaining robust content protection measures.

6.2 Watch Time Monitoring

AI technologies also play a pivotal role in monitoring watch time limitations. Streaming platforms often offer time-limited access to specific content, especially for promotional or rental purposes. AI systems can track the duration of content access and automatically revoke access once the allotted time has expired. This ensures that users adhere to the terms of their subscriptions or rentals, protecting the rights of content creators and distributors.

When a user rents a movie or accesses time-limited promotional content, the rental typically comes with a specified viewing window, such as 48 hours from the time of purchase. AI systems monitor the start time of the viewing window and continuously track the elapsed time. Once the rental period expires, the AI system automatically revokes access to the content, ensuring that users cannot view the material beyond the agreed-upon time frame. This automated enforcement of time limits prevents unauthorized extended access and ensures compliance with licensing agreements.

AI can also manage complex viewing scenarios where users might pause or stop watching content midway and resume later. The AI system keeps track of the total watch time, ensuring that the user only gets the stipulated amount of viewing time regardless of interruptions. For example, if a user starts watching a movie and pauses it halfway through, the AI system accurately tracks the remaining viewing time and continues the countdown when the user resumes watching. This precise monitoring ensures that the rental terms are strictly enforced, preventing any loopholes that could be exploited for extended viewing.

Moreover, AI-driven watch time monitoring helps in managing promotional content. Streaming platforms often release new content for a limited time as part of marketing campaigns or special events. AI systems can enforce the time limits for these promotional offers, ensuring that the content is only available for the intended duration. Once the promotional period ends, access to the content is automatically revoked, preserving the exclusivity and value of the promotion.

AI also enhances user experience by providing timely reminders and notifications about impending watch time limits. For instance, users might receive notifications when their rental period is about to expire or when they have limited time remaining to watch promotional content. These reminders help users make informed decisions about their viewing schedules and avoid sudden interruptions due to expired access.

User ID	Content ID	Downloads Exceeded	Watch Time Exceeded	Action Taken
001	301	No	Yes	Access Revoked
002	302	Yes	No	Download Restricted
003	303	No	No	No Action
004	304	Yes	Yes	Access Revoked
005	305	No	No	No Action

Table 4. Download and Watch Time Enforcement

VII. CASE STUDY: NETFLIX AND AMAZON PRIME VIDEO

7.1 Netflix

Netflix's use of AI extends beyond content recommendations and security. The platform also leverages AI to enhance the overall user experience by personalizing the interface based on individual user preferences. This personalization includes tailored artwork for shows and movies, as well as customized content categories. These efforts not only improve user satisfaction but also help in maintaining user engagement, indirectly aiding in the fight against unauthorized access. By keeping users engaged and satisfied, Netflix reduces the likelihood of account sharing and other unauthorized behaviors.

Moreover, Netflix employs sophisticated machine learning models to predict and manage network traffic. By analyzing viewing patterns and peak usage times, these models help Netflix optimize content delivery, ensuring smooth streaming experiences even during high-demand periods. This proactive management of network resources is crucial for maintaining service quality and deterring users from seeking pirated content due to buffering or downtime.

Netflix's AI-driven watermarking and fingerprinting techniques are particularly advanced. The platform uses perceptual hashing algorithms to generate unique fingerprints for each piece of content. These fingerprints are based on audio and video features that remain consistent even if the content is modified or re-encoded. Netflix's AI systems continuously scan the internet for these fingerprints, identifying and flagging unauthorized copies of its content. Once identified, Netflix can take swift legal action to remove infringing content, protecting its intellectual property and revenue streams.

7.2 Amazon Prime Video

Amazon Prime Video's integration of AI into its platform is equally comprehensive. One of the standout features of Amazon's AI application is its use of machine learning for content discovery. Amazon's AI algorithms analyze vast amounts of user data, including search history, viewing habits, and even customer reviews, to provide highly personalized content recommendations. This not only enhances user satisfaction but also helps in identifying and preventing suspicious activities related to unauthorized access.

Amazon Prime Video also employs AI to manage and optimize its content delivery network (CDN). By predicting viewing demand and dynamically adjusting server resources, Amazon ensures high-quality streaming experiences for its users. This network optimization reduces latency and buffering, making it less likely for users to seek out pirated versions of content due to poor streaming quality.

In terms of content protection, Amazon Prime Video uses advanced watermarking and fingerprinting techniques similar to those used by Netflix. These techniques involve embedding invisible markers within the content that are unique to each piece of media. Amazon's AI systems then use these markers to track and identify unauthorized copies of its content across the internet. When a pirated version is detected, Amazon can trace it back to the source, allowing for effective takedown actions and legal measures.

Additionally, Amazon Prime Video's AI-driven dynamic pricing strategy is a key component of its DRM efforts. By analyzing user data, Amazon can offer personalized pricing models that cater to different segments of its user base. This includes customized subscription plans, pay-per-view options, and special offers based on viewing habits and preferences. This flexibility in pricing not only maximizes revenue but also enhances user satisfaction, making it less likely for users to resort to unauthorized means to access content.

Amazon's enforcement of download and watch time limitations is another area where AI plays a crucial role. By continuously monitoring user interactions and behavior, Amazon's AI systems ensure that content access is strictly controlled according to the terms of the user's subscription or rental agreement. This includes preventing users from exceeding download limits and ensuring that watch time restrictions are adhered to. This level of control helps protect the rights of content creators and distributors while providing a fair and consistent user experience.

VIII. CONCLUSION

As streaming platforms continue to dominate the media landscape, the need for robust content protection and digital rights management solutions becomes increasingly critical. AI technologies offer powerful tools for preventing unauthorized access, managing digital rights, and enforcing download and watch time limitations. By leveraging AI, platforms like Netflix and Amazon Prime Video can safeguard their content, ensure compliance with licensing agreements, and provide a seamless viewing experience for their users.

However, the implementation of AI in content protection and DRM is not without challenges. One significant challenge is the constantly evolving nature of piracy techniques. As AI systems become more sophisticated in detecting and preventing unauthorized access, pirates also develop more advanced methods to bypass these security measures. This cat-and-mouse game requires continuous advancements in AI technologies and the development of more resilient algorithms capable of adapting to new threats in real-time.

Data privacy concerns also present a major hurdle. The use of AI for monitoring user behavior, enforcing download and watch time limitations, and personalizing content recommendations involves the collection and analysis of vast amounts of user data. Ensuring the protection of this data and maintaining user trust is paramount. Streaming platforms must implement stringent data privacy policies and comply with regulations such as the General Data Protection Regulation (GDPR) to safeguard user information while effectively utilizing AI for content protection.

Moreover, the integration of AI into existing DRM systems requires significant investment and expertise. Developing and maintaining AI-driven solutions is resource-intensive, necessitating a skilled workforce capable of managing complex AI models and large datasets. Streaming platforms must invest in continuous training and development programs to equip their teams with the necessary skills and knowledge to harness the full potential of AI technologies.

Another critical aspect is the need for collaboration between industry stakeholders. The fight against piracy and unauthorized distribution is a collective effort that involves content creators, distributors, technology providers, and regulatory bodies. Collaborative initiatives, such as industry-wide standards for watermarking and fingerprinting, can enhance the effectiveness of AI-driven content protection strategies. Sharing best practices, threat intelligence, and technological advancements can also strengthen the overall security framework for digital content distribution.

Ultimately, the successful implementation of AI in content protection and DRM will depend on the ability of streaming platforms to balance technological innovation with ethical considerations, user privacy, and industry collaboration. By doing so, platforms like Netflix and Amazon Prime Video can not only protect their valuable content but also foster a sustainable and secure digital media environment that benefits content creators, distributors, and consumers alike.

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