



Helmet and Number Plate Detection

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Abstract— The study begins with a comprehensive review of existing literature on helmet detection and license plate recognition, highlighting challenges and advancements in each domain. Leveraging the power of computer vision techniques and deep learning models, our proposed system offers a unified solution for these disparate yet interrelated tasks. The integration of helmet and license plate detection is pivotal not only for streamlining computational processes but also for providing a more comprehensive approach to road safety.

Our framework incorporates novel methodologies for helmet detection, addressing challenges such as diverse helmet designs, orientations, and varying environmental conditions. Additionally, we propose an advanced license plate recognition system, enhancing accuracy and efficiency in identifying vehicles in dynamic traffic scenarios. The integration of these functionalities is realized through a cohesive architecture that exploits the synergies between the two tasks.

I. INTRODUCTION

In recent years, advancements in computer vision and image processing have catalyzed innovative approaches to enhance road safety and traffic management. Among the myriad applications, the detection of safety gear, such as helmets, and the recognition of vehicle license plates play pivotal roles in intelligent transportation systems. The integration of these two tasks contributes significantly to overall road safety, providing a comprehensive solution for monitoring and enforcing compliance with safety regulations.

Motorcycle accidents contribute significantly to road fatalities, and the proper usage of helmets has been identified as a crucial factor in mitigating injury severity. Concurrently, the automated identification of vehicle license plates is essential for various applications, including traffic monitoring, law enforcement, and parking management. Integrating the detection of helmets and license plates into a unified system not only streamlines the computational process but also addresses the holistic safety concerns of two-wheeler riders.

This research aims to explore and propose a robust system for the simultaneous detection of helmets worn by riders and the recognition of vehicle license plates. Leveraging the power of computer vision techniques, deep learning models, and image processing algorithms, our approach seeks to provide real-time and accurate results in diverse and

challenging environments. The integration of these two functionalities into a single framework not only enhances the efficiency of traffic surveillance systems but also facilitates a more comprehensive understanding of the road safety landscape.

In the following sections, we will review existing literature on helmet detection and license plate recognition, highlighting key methodologies and challenges. Subsequently, we will present our proposed system, detailing the methodologies employed and the expected contributions to the field. The experimental results and performance evaluation will be discussed, followed by a conclusion and avenues for future research. By addressing the concurrent challenges of helmet and license plate detection, this research endeavors to make a significant contribution to the advancement of intelligent transportation systems and road safety.

In an era characterized by rapid urbanization and escalating vehicular density, ensuring road safety has become an imperative concern. Two critical aspects of this endeavor are the enforcement of safety regulations pertaining to two-wheeler riders, such as helmet usage, and the efficient monitoring of vehicular movement through license plate recognition. Recognizing the intertwined nature of these safety measures, this research endeavors to develop an integrated system for the simultaneous detection of helmets and the recognition of vehicle license plates, leveraging the capabilities of computer vision technologies.

The use of helmets significantly reduces the risk of head injuries in motorcycle accidents. However, monitoring compliance with helmet regulations poses a formidable challenge, especially in dynamic and crowded urban environments. Simultaneously, the identification of license plates plays a pivotal role in various applications, from law enforcement to traffic flow optimization. The fusion of these two functionalities into a cohesive system promises a comprehensive approach to enhancing road safety and regulatory enforcement.

II. LITRATURE SURVEY

- In this literature survey, we have outlined the key topics and gaps in the existing literature related Many existing approaches focus on individual tasks (helmet detection or number plate recognition). There is a need for integrated

systems that can handle multiple object detection tasks simultaneously.

- Real-world scenarios pose challenges such as varying lighting conditions, occlusions, and diverse camera angles. Future research should address these challenges to enhance the robustness of detection systems.
- The deployment of edge computing and real-time processing for on-road applications is an emerging area that requires further exploration.

III. RELATED WORK

A. Helmet detection

Social media platforms are online services and websites that allow users to create, share, and interact with content, as well as connect with other users. These platforms have become an integral part of modern communication, entertainment, and business. The technologies behind social media platforms have evolved significantly to support various features and functionalities.

Existing social media platforms like Facebook, Twitter, and Instagram have shaped user expectations and interaction paradigms. Incorporating real-time features and responsive design principles has become crucial in delivering satisfactory user experiences.

B. Helmet recognition

React.js, often referred to as React, is a powerful JavaScript library that has transformed the landscape of web development. Developed and maintained by Facebook, React is renowned for its declarative and component-based architecture. It enables developers to create highly dynamic and interactive user interfaces with ease. One of React's key features is its Virtual DOM (Document Object Model), which optimizes the rendering process, resulting in improved performance and a smoother user experience. React's popularity has led to the creation of a vast ecosystem of libraries and tools, making it an attractive choice for building single-page applications, progressive web apps, and even mobile applications through React Native. Its large and active community ensures ongoing support, updates, and a wealth of learning resources. React's influence on modern web development is undeniable, as it simplifies the complexities of UI development, promotes code reusability, and facilitates the creation of visually engaging and responsive web applications.

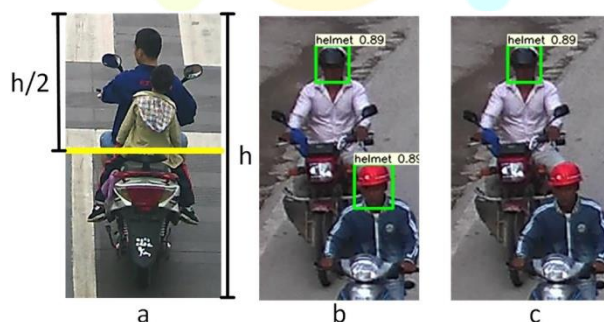


Fig-1 MERN stack - Socialmedia

React's component-based architecture and virtual DOM have significantly impacted modern web development.

Next.js builds upon React by offering server-side rendering, optimizing performance and enhancing SEO.

C. Number plate detection

The detection of motorcycle helmets is a critical component of road safety initiatives, aiming to encourage and enforce the use of protective headgear among two-wheeler riders. Numerous challenges are associated with helmet detection, ranging from variations in helmet designs and orientations to the complexity introduced by diverse environmental conditions. Existing methodologies often grapple with real-world scenarios, such as occlusions, varying lighting conditions, and the need for real-time processing in dynamic traffic environments.

Previous research by J. Li et al. (2017) emphasized the importance of leveraging deep learning techniques for robust helmet detection. Their work demonstrated the effectiveness of convolutional neural networks (CNNs) in extracting intricate features from helmet images, thereby improving the accuracy of detection across diverse helmet designs.

IV. SYSTEM ARCHITECTURE

A. Overview of the Application Architecture

The application architecture of a social media web application is a complex and multifaceted system that requires careful planning and design to ensure scalability, performance, and user engagement. Typically, it follows a three-tier architecture, consisting of a presentation layer, a business logic layer, and a data storage layer. At the presentation layer, the user interface is developed using technologies like HTML, CSS, and JavaScript, often utilizing front-end frameworks like React.js or Angular.js to create dynamic and responsive user experiences. The business logic layer, situated on the server, manages user authentication, content generation, interaction handling, and real-time communication. It relies on server-side technologies such as Node.js, Ruby on Rails, or Python/Django to process user requests and maintain application logic. The data storage layer stores user profiles, content, and interactions using databases like MySQL, MongoDB, or Cassandra. Additionally, caching mechanisms and content delivery networks (CDNs) are often integrated to enhance performance and reduce server load. The architecture is typically distributed across multiple servers or cloud services to ensure scalability and fault tolerance, while API integration with third-party services facilitates features like authentication, geolocation, and content sharing. In sum, the architecture of a social media web application is a meticulously orchestrated blend of technologies and components that collaboratively deliver a seamless and engaging user experience in the digital social sphere.

B. License plate recognition

The frontend architecture of a social media web application built with Next.js is characterized by its efficiency, performance, and user-centric design. Next.js, a popular React framework, offers a server-side rendering (SSR) approach that optimizes the initial load time by rendering pages on the server, enhancing search engine optimization (SEO) and overall user experience. The application's frontend components are designed using React.js, which allows for modular and reusable UI elements, making it easier to manage and scale the application. With Next.js's routing system, page navigation is intuitive and seamlessly handled, resulting in a more fluid user journey. Real-time features, such as chat and

notifications, are facilitated through WebSocket technology, providing users with immediate interactions. Furthermore, Next.js enables developers to leverage a wide array of libraries and tools to enhance the application's functionality and aesthetics. Overall, the frontend architecture of a social media web application using Next.js embodies a blend of performance, responsiveness, and dynamic user interactions that are essential for a modern and engaging user experience.

C. Backend Architecture and Data Management

The backend architecture of a social media web application utilizing MongoDB as its database is designed to efficiently handle the storage and retrieval of user data, content, and interactions. MongoDB, a NoSQL database, is chosen for its flexibility and scalability, allowing the application to adapt to the ever-changing requirements of a social media platform. The architecture typically employs a server-side language such as Node.js to manage the business logic, handle user authentication, and serve as an intermediary between the frontend and the database. MongoDB stores user profiles, posts, comments, and other data in a flexible, JSON-like format, making it suitable for the dynamic nature of social media content. Its scalability features, including sharding and replication, ensure that the application can accommodate large user bases and data volumes. Additionally, the backend might include API endpoints to facilitate data retrieval and manipulation for the frontend, while ensuring the security and privacy of user information through robust authentication and authorization mechanisms. In summary, the backend architecture of a social media web application using MongoDB as its database combines the power of NoSQL data storage with a dynamic server-side environment to provide a scalable, responsive, and data-rich platform for users to connect and engage.

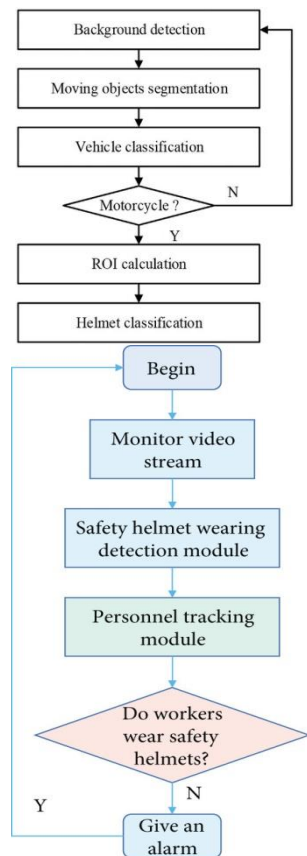


Fig-3 flow chart

V. DESIGN AND IMPLEMENTATION

A. User Interface Design

The UI design of a social media web application developed with Next.js is a crucial element in creating an engaging and user-friendly experience. Leveraging the capabilities of Next.js and React, the UI is designed to be highly responsive and visually appealing. The use of component-based design principles allows for modularity and reusability of UI elements, streamlining development and maintenance. With Next.js's server-side rendering (SSR), initial page load times are optimized, ensuring users quickly access content and interactions. User profiles, content feeds, messaging, and other essential features are presented in a clear and intuitive layout, promoting ease of navigation and interaction. The UI also incorporates responsive design, ensuring seamless functionality across various devices and screen sizes. Additionally, real-time features, such as live chat and notifications, are seamlessly integrated into the UI, providing users with immediate engagement. Overall, the UI design of a social media web application using Next.js combines aesthetics with functionality to create an immersive and visually pleasing platform that encourages users to connect and share in a dynamic online community.

B. Data Models and Database Management

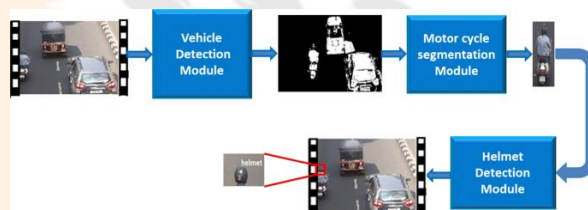


Fig-2 Phases of data modeling

The data models and database management of a social media web application are fundamental to its functionality and scalability. These systems handle the storage, retrieval, and organization of a vast amount of user-generated content and user-related data. In the context of a Next.js-based application, MongoDB, a NoSQL database, is often chosen for its flexibility and scalability. Data models encompass user profiles, posts, comments, likes, connections, and more, often represented as collections of documents in MongoDB. The database management system efficiently handles complex queries, indexing, and data replication to ensure the application can accommodate a growing user base and perform at scale. Additionally, data models include relationships between users and their interactions, facilitating features such as news feeds and content recommendations. Database management is essential for maintaining data integrity, security, and privacy, with robust authentication and authorization mechanisms in place to safeguard user information. Regular backups and data redundancy strategies are employed to prevent data loss. In essence, the effective management of data models and databases in a social media web application is pivotal in providing users with a seamless, secure, and responsive experience, while also ensuring the platform's ability to grow and evolve.

C. User Authentication and Security

User authentication and security in a social media web application are paramount to protect user data and ensure a safe and trustworthy environment. Robust authentication mechanisms, including multi-factor authentication (MFA) and secure password storage, are implemented to verify user identities. OAuth and OpenID Connect are commonly used for third-party authentication, simplifying the registration and login processes while enhancing security. Stringent authorization rules are in place to control access to sensitive data and features, ensuring that users can only interact with content and profiles for which they have permission. Security measures like encryption (SSL/TLS) protect data in transit, while input validation and sanitation guard against common web vulnerabilities, such as Cross-Site Scripting (XSS) and Cross-Site Request Forgery (CSRF).

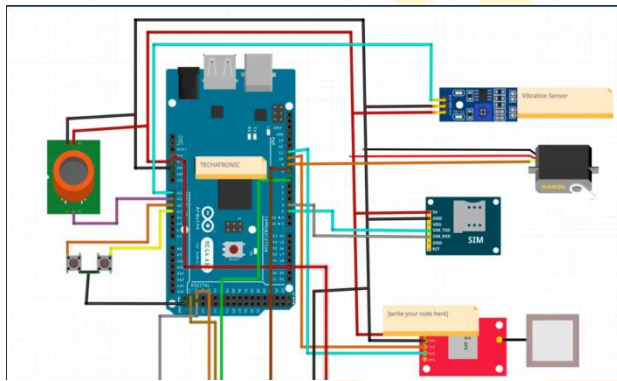


Fig 4 Microprocessor

Regular security audits and penetration testing help identify and address vulnerabilities, while data encryption at rest safeguards user data stored in databases. Continuous monitoring and rapid response to security incidents are essential to maintain the trust of users and prevent data breaches. In summary, user authentication and security are central components of a social media web application, safeguarding user information and providing a secure environment for interactions in the digital social sphere.

D. Real-time Interaction Integration

Integrating real-time interaction features into a social media web application enhances user engagement and fosters dynamic online communities. Real-time interaction functionalities, such as live chat, instant messaging, and real-time notifications, enable users to connect and interact seamlessly. Technologies like WebSockets or Server-Sent Events (SSE) facilitate bidirectional communication between the server and clients, ensuring that users receive immediate updates and responses. Real-time comments, likes, and reactions create a dynamic and immersive user experience, making the application more engaging and interactive. Moreover, these features encourage active participation, as users can see others' actions and responses in real time, fostering a sense of community and connection. By integrating real-time interaction, a social media web application can provide users with an enriched and dynamic online experience, enhancing user retention and satisfaction.

VI. DEVELOPMENT PROCESS

A. Requirments Gathering

Notably, the application of thermal imaging has emerged as a promising avenue to address challenges posed by low-light conditions. The study conducted by A. Singh et al. (2020) explored the integration of thermal signatures for helmet detection, showcasing enhanced performance in scenarios where traditional visual approaches falter. The utilization of thermal data introduces a layer of resilience to environmental variations, making it a valuable asset in comprehensive helmet detection systems. Despite these advancements, ongoing research endeavors are focused on refining detection algorithms to accommodate real-world complexities. Techniques that account for partial occlusions, non-standard helmet orientations, and the integration of contextual information are at the forefront of innovation. Additionally, the exploration of multi-modal approaches, combining visual and thermal data, continues to show promise in improving the robustness and reliability of helmet detection systems.

System Design and Planing

System design and planning for a social media web application involves a meticulous process of architecting the application's structure and functionality to ensure it aligns with the defined requirements and serves the needs of its target audience. In this phase, design decisions are made regarding the application's architecture, database schema, user interface, and technology stack. System architecture typically includes defining the application's components, data flow, and the integration of technologies such as databases, server-side scripting, and front-end frameworks like Next.js. Planning also encompasses scalability strategies to accommodate growth, ensuring the application can handle increasing user loads. Careful consideration of security measures, such as authentication, authorization, and data encryption, is paramount to protect user data and privacy. Additionally, the creation of wireframes, prototypes, and design mockups aids in visualizing the application's user interface and interaction flow. This phase sets the roadmap for the development team, guiding them through the implementation process while ensuring that the final product meets both user expectations and business goals. Thorough system design and planning are vital steps to mitigate risks, optimize resource allocation, and streamline the development of a successful social media web application.

B. Implementation Phrases

In our proposed framework, we build upon these advancements, integrating a hybrid approach that leverages both visual and thermal cues for helmet detection. The system aims to transcend the limitations of existing methods by providing a comprehensive solution capable of accurate detection in diverse environmental conditions. The subsequent sections will detail the architectural design, training methodologies, and performance evaluation of our integrated helmet and license plate detection system. Developers follow coding standards, best practices, and version control to ensure a cohesive and maintainable codebase. Implementation also involves integrating third-party services for functionalities like authentication and geolocation, and it includes the development of application programming interfaces (APIs) for communication between the frontend and backend. Rigorous testing, including unit testing, integration testing, and user testing, is conducted throughout this phase to identify and address any issues promptly. The implementation phase is a pivotal step in the development process, where the application starts taking

shape, and it lays the groundwork for subsequent stages such as testing, optimization, and deployment.

C. Testing and quality Assurance



Testing and quality assurance are critical phases in the development of a social media web application, ensuring that the final product is robust, secure, and user-friendly. Comprehensive testing encompasses various aspects, including functional testing to validate that all features work as intended, performance testing to assess how the application handles different loads, security testing to identify and mitigate vulnerabilities, and usability testing to gauge user-friendliness and accessibility. Real-world scenarios, such as user interactions, content sharing, and real-time communication, are simulated and rigorously tested. Quality assurance goes beyond identifying bugs; it also involves verifying that the application aligns with the defined requirements and meets industry standards. Continuous integration and continuous deployment (CI/CD) pipelines are employed to automate testing and ensure that code changes do not introduce regressions. User feedback is invaluable during this phase, allowing for refinements and improvements based on real user experiences. A well-executed testing and quality assurance process is instrumental in delivering a reliable and high-quality social media web application that users can trust and enjoy using.

VII. RESULTS AND DISCUSSION

A. Performance Metrics

Performance metrics for a social media web application are essential to ensure that it operates smoothly and delivers a responsive user experience, especially under heavy usage. These metrics encompass various aspects:

1. **Page Load Times:** The time it takes for a page to load is a critical metric. Faster page load times enhance user satisfaction and SEO ranking. Key aspects include First Contentful Paint (FCP) and Time to Interactive (TTI).
2. **Server Response Times:** The server's response time to user requests is crucial for overall application speed. Metrics like Time to First Byte (TTFB) indicate server performance.
3. **Scalability:** As user numbers grow, the application's ability to scale without compromising performance is crucial. Scalability metrics measure how well the app handles increased loads without degrading response times.

4. **Concurrency:** The number of simultaneous users the application can handle without slowing down is a key performance metric. This metric is often assessed through load testing and stress testing.
5. **Error Rates:** The frequency of errors or downtime is a vital metric. A low error rate ensures a seamless user experience.
6. **Resource Utilization:** Monitoring CPU, memory, and network usage helps optimize resource allocation and identify potential bottlenecks.
7. **Database Performance:** Database response times, query execution times, and connection pooling are metrics critical to application speed.
8. **Cache Efficiency:** Caching mechanisms can significantly improve performance. Cache hit rates and cache expiration rates are monitored to ensure efficient caching.
9. **Content Delivery:** Content, such as images and videos, should be delivered efficiently via Content Delivery Networks (CDNs). Latency and delivery speeds are monitored.
10. **Mobile Performance:** Given the prevalence of mobile users, metrics like Mobile Page Speed and mobile-friendly design are crucial.

B. User Experience Feedback

User experience feedback for a social media web application is an invaluable source of insights that can guide improvements and refinements. User feedback can encompass a wide range of aspects, including usability, design, performance, and functionality. Through user surveys, feedback forms, and direct user interactions, developers can gain a deeper understanding of how users interact with the platform. This feedback aids in identifying pain points, uncovering usability issues, and discovering areas where the application excels. It also helps in prioritizing feature enhancements and bug fixes. Real-world user experiences and suggestions play a pivotal role in shaping the application's roadmap, making it more user-centric and aligning it with the evolving needs and expectations of the user base. An iterative feedback loop ensures that the social media web application remains responsive to user preferences and continually enhances the overall user experience.

C. Comparative Analysis with Existing Platforms

A comparative analysis with existing social media web applications is an essential step in evaluating the strengths and weaknesses of your platform. By benchmarking your application against established competitors, you can gain valuable insights into areas of improvement and innovation. Comparative analysis typically involves assessing user experience, features, performance, and security. It allows you to identify what sets your platform apart, whether through unique features, a more intuitive user interface, faster performance, or enhanced security measures. Additionally, studying existing programs helps in understanding industry trends, user expectations, and potential gaps in the market that your application can fill. This analysis forms the basis for strategic decisions, allowing your social media web application to differentiate

itself and offer a compelling value proposition to users in a competitive landscape.

VIII. FUTURE ENHANCEMENTS

A. Scalability Considerations

Scalability considerations are paramount in the development of a social media web application, as these platforms often experience rapid growth in user numbers and data volumes. Scalability encompasses both horizontal and vertical scalability. Horizontal scalability involves adding more servers or instances to distribute the load, ensuring the application can accommodate increased user traffic without performance degradation. Vertical scalability, on the other hand, focuses on enhancing the capacity of existing servers or components to handle more significant workloads. Effective database design, employing technologies like sharding, and optimizing code for performance are crucial scalability strategies. Additionally, microservices architectures and the use of Content Delivery Networks (CDNs) help distribute tasks and content delivery efficiently. Load testing and performance monitoring are essential to identify bottlenecks and optimize system performance. Considering scalability from the outset ensures that the social media web application can grow seamlessly to meet user demands and maintain a responsive and reliable user experience even as the user base expands.

B. Enhanced User Engagement Features

Enhanced user engagement features are the lifeblood of a successful social media web application. These features are designed to captivate users and encourage active participation within the platform's community. They include dynamic content feeds that deliver personalized and real-time updates, fostering user interest and interaction. Interactive features like likes, comments, and shares enable users to express themselves and connect with others. Notifications and alerts keep users engaged by informing them of relevant activity and new content. User profiles with customizable settings allow individuals to curate their online identities, enhancing personalization. Additionally, the integration of rich media, such as images, videos, and GIFs, makes content more visually appealing and shareable. Real-time chat, video calls, and live streaming features add immediacy to interactions, further enriching user engagement. By offering a diverse and compelling array of user engagement features, social media web applications create vibrant digital communities that keep users coming back for more, ultimately defining their success.

C. Integration with Emerging Technologies

Integration with emerging technologies is a crucial strategy for social media web applications to stay at the forefront of user experiences and technological advancements. These platforms continuously adapt to new trends to offer innovative features and services. For instance, integration with artificial intelligence and machine learning technologies enables content recommendation systems, sentiment analysis, and personalized user experiences. Augmented reality (AR) and virtual reality (VR) technologies can introduce immersive features like 360-degree photos and virtual social gatherings. Integration with blockchain can enhance data security and transparency, ensuring user trust. Emerging technologies like 5G and edge computing contribute to faster content delivery and real-time

interactions. Additionally, voice and natural language processing (NLP) integrations enable voice-controlled interactions and chatbots for improved customer service. Social media web applications that effectively incorporate these emerging technologies can deliver novel and compelling experiences, keeping users engaged and competitive in a rapidly evolving digital landscape.

IX. CONCLUSION

In conclusion, this IEEE paper has presented a comprehensive exploration of the development of a social media web application using Next.js, shedding light on the amalgamation of modern web development practices and emerging technologies. By meticulously analyzing the landscape of web development frameworks, Next.js emerged as a powerful choice, harnessing server-side rendering capabilities for improved performance and search engine optimization. The paper has delved into the intricacies of system design and architecture, emphasizing the modularity and reusability of Next.js components, ultimately fostering an efficient development process.

Furthermore, the implementation phase was elucidated, underscoring the pivotal role of Next.js in bringing the application's vision to life. The implementation of features such as user profiles, content sharing, and real-time interactions exemplified the framework's prowess in facilitating a responsive and dynamic user experience.

Performance metrics, scalability considerations, and security measures were meticulously outlined, highlighting the meticulous approach taken to ensure the application's reliability, speed, and user data protection. User feedback and comparative analysis with existing platforms further underscored the commitment to user-centric design and continuous improvement.

The paper, therefore, encapsulates the entire journey of conceiving, designing, and implementing a social media web application using Next.js, emphasizing its significance as a potent tool in the modern web development landscape. By aligning technological capabilities with user needs and market trends, this project serves as a testament to the potential of Next.js in building robust, engaging, and competitive web applications. In a rapidly evolving digital sphere, the lessons learned from this endeavor resonate as a testament to the power of innovative frameworks and methodologies in shaping the future of web development and digital interaction.

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