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Modernization of Adoption Processes in Animal Shelters: A User-Friendly Mobile Application Approach

Kenan ERİN^{*1} , Janberk ALTAY² , Buse SARI² 

¹ Tarsus University, Department of Mechanical Engineering, Tarsus, Turkey, kenanerin@tarsus.edu.tr

² Tarsus University, Department of Computer Engineering, Tarsus, Turkey, janberk.altay@gmail.com

³ Tarsus University, Department of Computer Engineering, Tarsus, Turkey, saribuse33@gmail.com

ABSTRACT

This study introduces a technological solution designed to overcome the operational bottlenecks in the rehabilitation and permanent placement of stray animals. To address the accessibility and transparency limitations inherent in conventional shelter management, a user-centered mobile platform was developed using the Flutter framework and Firebase database infrastructure. The project incorporates integrated application forms and comprehensive animal profiles to streamline the adoption process and bolster public awareness. System evaluations demonstrated highly responsive performance, with an average application launch time of approximately 1.8 seconds, and all nine functional test scenarios were successfully validated. Following the sharing of these findings with local authorities—specifically the Municipality of Tarsus—the project was successfully integrated into the municipality’s social responsibility initiatives

Keywords: Mobile Application, Animal Welfare, Flutter, Firebase, Digital Adoption

* Corresponding Author’s email: kenanerin@tarsus.edu.tr

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1. Introduction

Globally, millions of cats and dogs enter animal shelters annually, with a significant proportion remaining confined for extended periods due to low adoption rates. This trend not only poses severe welfare challenges for the animals but also precipitates resource and capacity crises within shelter systems [1, 2]. Given the substantial stray animal population in Türkiye, the efficacy of conventional adoption methods has come under scrutiny, leading to a growing interest in the potential of digital transformation to address these systemic challenges [3]

Existing adoption systems predominantly rely on in-person applications and provide fragmented information regarding the animals, thereby complicating the tracking of the adoption process. Such inefficiencies often deter potential adopters and further exacerbate the strain on shelter capacities [7]. While integrating digital platforms into these workflows offers the potential for structural solutions, evidence-based research investigating the impact of such interventions remains scarce [2]

Animal adoption processes are of multidimensional importance, spanning animal welfare, population control, and public health. An effective adoption framework secures permanent domestic environments for sheltered animals, addressing their physiological and behavioral needs while significantly enhancing their quality of life. Simultaneously, by curbing uncontrolled reproduction, systematic adoption maintains stray populations at sustainable levels and mitigates the resource scarcities precipitated by shelter overcrowding. Furthermore, ensuring that adopted animals are integrated into regular veterinary supervision and vaccination schedules reduces the risk of zoonotic disease transmission. Consequently, adoption serves as a strategic, albeit indirect, intervention for the protection of public health

Facilitating adoption operations via digital platforms provides a robust operational solution by broadening accessibility, ensuring procedural transparency, and accelerating the overall adoption timeline. Unlike conventional methods, digitalization disseminates animal profiles to a more diverse audience, empowering potential adopters to identify suitable shelter animals more rapidly and make better-informed decisions. This technological shift enables animals to be placed in permanent homes more efficiently, thereby optimizing animal welfare while simultaneously alleviating shelter overcrowding and fostering long-term social impact. To contextualize these developments, the existing literature was reviewed systematically; a summary of the relevant research is presented below.

Dingrui et al. introduced a digitalized adoption framework aimed at optimizing animal welfare and streamlining adoption procedures [1]. By aligning technological intervention with social responsibility and sustainable development goals, their methodology provides significant contributions to the academic discourse while simultaneously heightening public awareness regarding animal stewardship.

More et al. developed the 'ART' application, which serves as a specialized interface connecting animal shelters with prospective adopters to formalize and systematize the adoption process [2]. By facilitating these connections, the platform promotes responsible pet ownership and heightens public consciousness regarding animal welfare. Furthermore, their work contributes to the burgeoning academic literature in this field by offering a scalable and sustainable model for assisting animals in transition.

Malwe et al. introduced the 'PawGuardian' application, which utilizes digital intervention to optimize canine adoption workflows, advocate for responsible pet ownership, and mitigate the challenges associated with pet overpopulation [4]. The platform fosters greater public sensitivity toward sheltered animals—thereby indirectly bolstering animal welfare and community health—while establishing a framework for systematic and scalable adoption practices

Yasa et al. engineered an Android-based adoption platform that utilizes machine learning algorithms to provide personalized recommendations and automated breed identification [5]. By integrating these advanced features, the proposed system seeks to optimize animal welfare and reinforce social responsibility initiatives focused on the care and rehoming of abandoned animals.

Blancaflor et al. showcased the efficacy of the 'CareForPaws' mobile application, which utilizes location-based technologies to optimize pet adoption and foster community engagement [6]. By leveraging geospatial data to connect local shelters with nearby adopters, the study advances the academic landscape of digital animal welfare while reinforcing the social responsibility frameworks fundamental to modern pet stewardship.

Jha et al. developed a mobile application specifically designed to facilitate adoption workflows, heighten public awareness of stray animal issues, and cultivate a sense of individual responsibility toward animal welfare [7]. This research aims to advance the scientific discourse on pet stewardship while simultaneously fostering sustainable, positive societal shifts in the perception and care of abandoned animals.

In parallel, artificial intelligence studies based on YOLOv11 demonstrate the potential of machine-learning algorithms for real-time detection and classification tasks [8]. Such approaches are particularly relevant to future versions of digital adoption platforms, where image-based animal identification, breed estimation, health-status screening, or adopter-animal matching could be incorporated as decision-support modules. Likewise, IoT-supported rehabilitation systems using iterative learning control illustrate how user-specific data can be monitored remotely and transformed into feedback for service providers [9]. This perspective supports the inclusion of structured feedback forms, municipal data exchange, and future data-driven monitoring mechanisms in PATILE.

To address the gaps identified in the existing literature, this study introduces 'PATILE,' an Android-based mobile application developed utilizing the Flutter framework and Firebase database infrastructure. The primary research question guiding this inquiry is: To what extent can a dedicated mobile platform enhance transparency and accessibility within animal shelter adoption workflows? To address this question, the study employs an integrated framework encompassing user-needs analysis, system architecture design, the development lifecycle, and an evaluation of the subsequent findings

2. Materials and Methods

This study employs a design-based research (DBR) approach focused on developing a user-centered mobile application to facilitate adoption processes within animal shelters. The methodology is grounded in a hybrid framework that integrates iterative software engineering principles with User-Centered Design (UCD)

methodologies.

2.1. Research Design

The study was structured around a five-stage iterative development cycle: (i) requirements elicitation, (ii) system design, (iii) prototyping and development, (iv) verification testing, and (v) stakeholder feedback. The output of each cycle informed the subsequent stage, thereby ensuring that design decisions were progressively refined. This approach was selected primarily because—unlike the linear progression of the conventional waterfall model—it facilitates the integration of user feedback during the early phases of the design process [2]. The independent variable was defined as the digital mediation facilitated by the mobile application (specifically adoption information transparency, process automation, and geographical accessibility), while the dependent variables were operationalized as functional adequacy, system performance, and stakeholder acceptance.

This iterative structure was not intended merely as a software-development sequence; it also provided a controlled framework for transforming user requirements into measurable system functions. Similar performance-oriented development logic is observed in adaptive control, AI-based detection, and IoT-enabled monitoring studies, where system outputs are refined through testing, feedback, and quantitative verification [8-11]. Therefore, PATILE was evaluated not only as a mobile interface but also as an applied digital system whose functional adequacy and responsiveness could be verified through predefined scenarios.

2.2. Comparative Systems Analysis

To establish an empirical foundation for design decisions, four mobile adoption applications currently active in Türkiye-PatiChat [13], Petner [14], Pets Adoption [15], and İBB SemtPati [16] were systematically evaluated. This comparative analysis was conducted across nine distinct dimensions: interface design, profile granularity, visual content support, feedback mechanisms, appointment functionality, educational modules, community engagement, and geographical filtering. Each application was assessed through direct installation and longitudinal observation, with identified strengths and weaknesses documented in a comparative matrix. The insights derived from this analysis were instrumental in both mapping the structural deficiencies of existing platforms and defining the comprehensive functional requirement set for PATILE.

2.3. Requirements Analysis

In this phase, semi-structured interviews were conducted with a purposive sample of potential users, comprising students at Tarsus University and residents of the Tarsus district. Participants were queried regarding their prior adoption experiences, their expectations of existing platforms, and the specific obstacles they had encountered. The resulting qualitative data were evaluated using thematic analysis; the predominant themes identified included the demand for granular animal profiles, expectations for transparency throughout the application lifecycle, the elimination of location-based constraints, and integrated access to educational resources. These themes provided direct input for the system architecture and user-flow design detailed in Sections 2.4 and 2.5.

2.4. System Architecture

The system architecture of PATILE is structured as a multilayered design, aligning with modern mobile application development paradigms where the front-end (client) and back-end layers are explicitly decoupled. Figure 1 illustrates the comprehensive architectural schematic of the system.

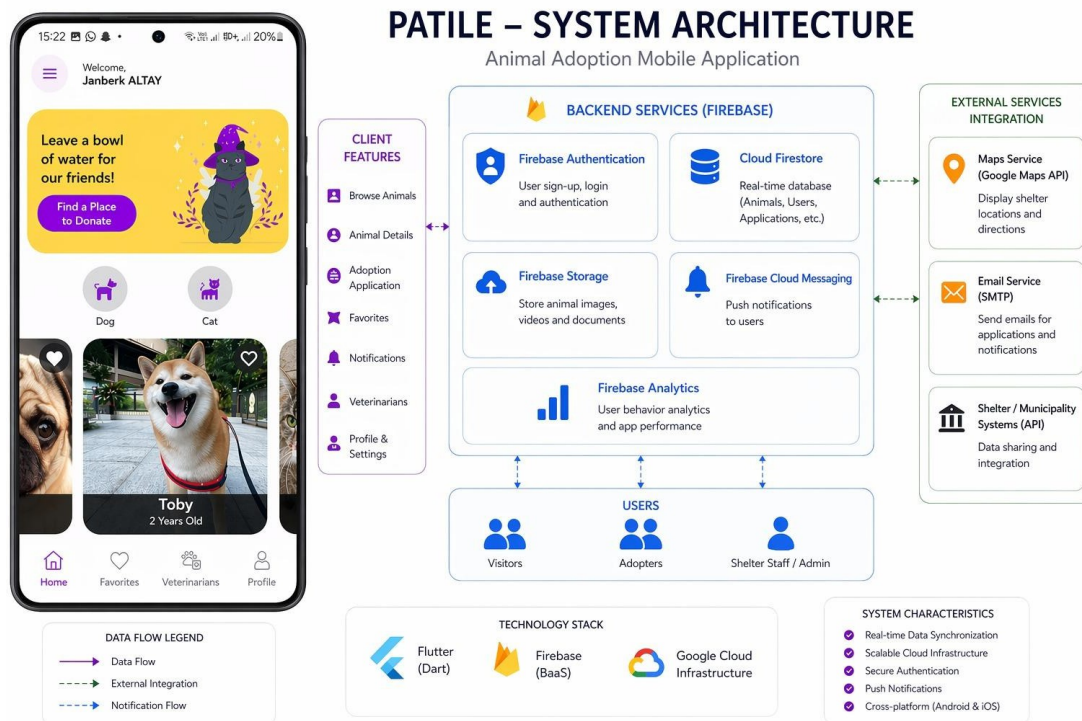


Figure 1. PATILE System Architecture

As illustrated in Figure 1, the system comprises three fundamental components: the client-side mobile application, Firebase-based back-end services, and external service integrations. The Flutter framework was selected for front-end development, primarily due to its cross-platform deployment capabilities from a single codebase, its extensive package ecosystem, and its high-performance rendering engine. Dart served as the underlying programming language.

For back-end operations, the Google Firebase platform was implemented following the Backend-as-a-Service (BaaS) model. This approach abstracted the complexities of server management and provided inherent real-time data synchronization. The architecture leverages five core Firebase modules: Firebase Authentication for secure credential-based access and token-based session management; Cloud Firestore for storing structured data—such as animal profiles and adoption records—and ensuring low-latency synchronization; Firebase Storage for the high-bandwidth delivery of multimedia content; Firebase Cloud Messaging (FCM) for push notifications; and Firebase Analytics for monitoring user interactions and system performance.

Furthermore, the system integrates three external services: the Google Maps API for geolocation and routing, an SMTP-based service for automated email communication, and external APIs for data exchange with municipal databases. Collectively, this architecture ensures a scalable, secure, and responsive environment optimized for real-time adoption management.

2.5. User-Flow Design

Complementing the system architecture, the user journey—representing the sequential stages of the adoption process within the application—was meticulously designed to ensure usability and efficiency. Figure 2 illustrates the comprehensive user-flow diagram, detailing the operational logic and decision nodes involved in the adoption workflow.

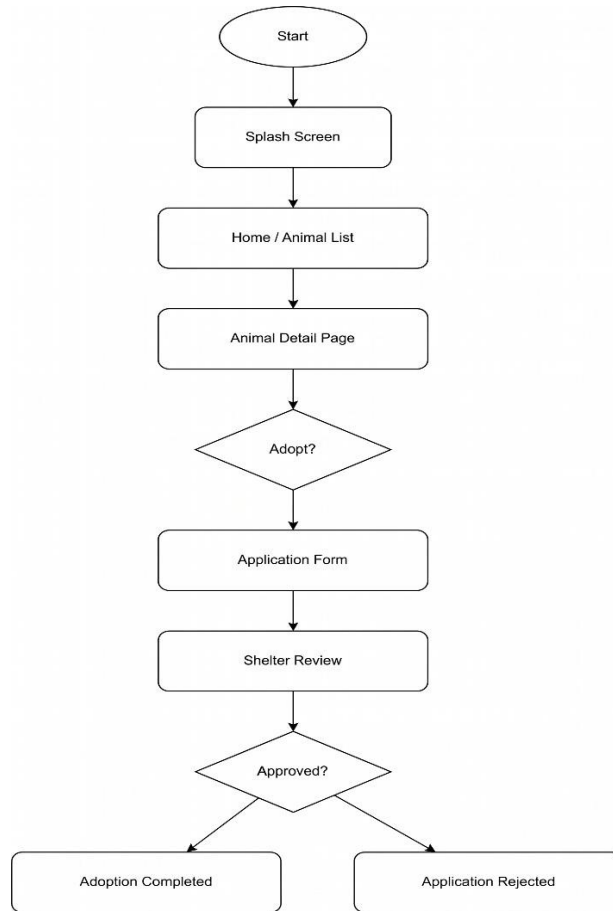


Figure 2. User-Flow Diagram of the Adoption Process

The workflow illustrated in Figure 2 encompasses every interaction point, from initial application launch to the finalization of the adoption process. The sequence commences with a splash screen that transitions the user to the primary dashboard. From the home screen, users can browse a comprehensive list of sheltered animals and navigate to individual profile pages. These detail pages provide granular data, including the animal's name, species, age, sex, clinical health status, temperament, and intake history.

Upon initiating an adoption request, the system prompts the user to complete a structured application form. This instrument captures qualitative indicators such as the applicant's living conditions, prior caretaking experience, and the prospective domestic environment. Following submission, the application enters an evaluation phase managed by authorized shelter personnel; the resolution is subsequently communicated to the user as either 'adoption finalized' or 'application declined.' This streamlined flow does not merely digitize the adoption pathway; it is strategically designed to uphold transparency and accountability at each procedural node

2.6. Development Process

The development lifecycle was segmented into eight distinct work packages distributed across a 12-month timeline. The initial two months were allocated to an extensive literature review and requirements elicitation. During the subsequent phase (Months 2–6), the UI/UX design was prototyped using Figma, while the Firebase back-end infrastructure was concurrently configured. From Month 7 through Month 10, the application's development via Flutter was finalized, Firebase integrations were established, and synthetic shelter data were populated within the Cloud Firestore database. The final two months (Months 11–12) were dedicated to rigorous functional and performance testing; any identified defects were systematically mitigated through iterative refinement cycles.

2.7. Verification Approach

The verification of the developed application was conducted across three distinct domains. The first domain, technical verification, involved the design and execution of nine functional test scenarios—including authentication, animal listing, profile display, filtering, favoriting, feedback submission, and mapping functionality—alongside performance benchmarking; these results are detailed in Table 2 (Section 3.4). The second domain, institutional validation, was performed via a formal presentation to officials from the Information Technology and Press Department of the Municipality of Tarsus, where stakeholder feedback was systematically documented. Finally, the third domain, social verification, was achieved through a pilot awareness event at the middle-school level. During this event, the application was introduced to the target audience, allowing for the direct observation and recording of user engagement and reactions

3. Findings and Discussion

3.1. Application Features and Comparison with Existing Systems

The systematic analysis of existing applications revealed several critical deficiencies: animal profiles reliant solely on static imagery, location-restricted listings, a lack of integrated feedback mechanisms, superficial educational content, and fragmented community engagement. PATILE was specifically architected to bridge these functional gaps.

Table 1 provides a comparative feature analysis of PATILE alongside contemporary platforms, namely PatiChat [13], Petner [14], Pets Adoption [15], and İBB SemtPati [16]. This comparison highlights the extent

to which PATILE integrates advanced functionalities that are currently absent or underdeveloped in the existing market.

Table 1: Comparative Analysis of Existing Applications and PATILE

Feature	PatiChat	Petner	Pets Adoption	İBB SemtPati	PATILE (This Study)
Interface Design	Complex and inconsistent	Vibrant but inconsistent	Lacks visual hierarchy	Vibrant but limited usability	Minimalist and User-Centered
Profile Detail	Basic	Basic	Basic	Detailed	Granular (Bio + Personality)
Visual Content	Static imagery only	Static imagery only	Static imagery only	Static imagery only	Multimedia (Photo + Video)
Feedback	Unavailable	Basic	Standardized survey	Unavailable	Advanced/Customizable Form
Location Filter	Regional (Fixed)	Regional (Fixed)	Regional (Fixed)	District-restricted	Extended/Dynamic Range

The comparative analysis in Table 1 illustrates that PATILE offers substantial improvements over contemporary platforms in four primary domains: (1) multimodal media support, incorporating high-definition video content; (2) comprehensive animal profiling, which integrates granular temperament and training-history data; (3) dynamic geographical filtering, designed to mitigate traditional location-based constraints; and (4) an integrated feedback architecture that ensures transparency throughout the adoption lifecycle.

3.2. User-Interface Design of the Developed Application

The primary user interfaces of the PATILE application, architected in accordance with the design specifications derived from the comparative analysis in Section 3.1, are illustrated in Figure 3. The figure showcases four pivotal screens, sequenced from left to right to mirror the stages of the user journey: the authentication (login) portal, the personalized 'favorites' dashboard, the comprehensive animal-profile page, and the geospatial map of nearby veterinary services.

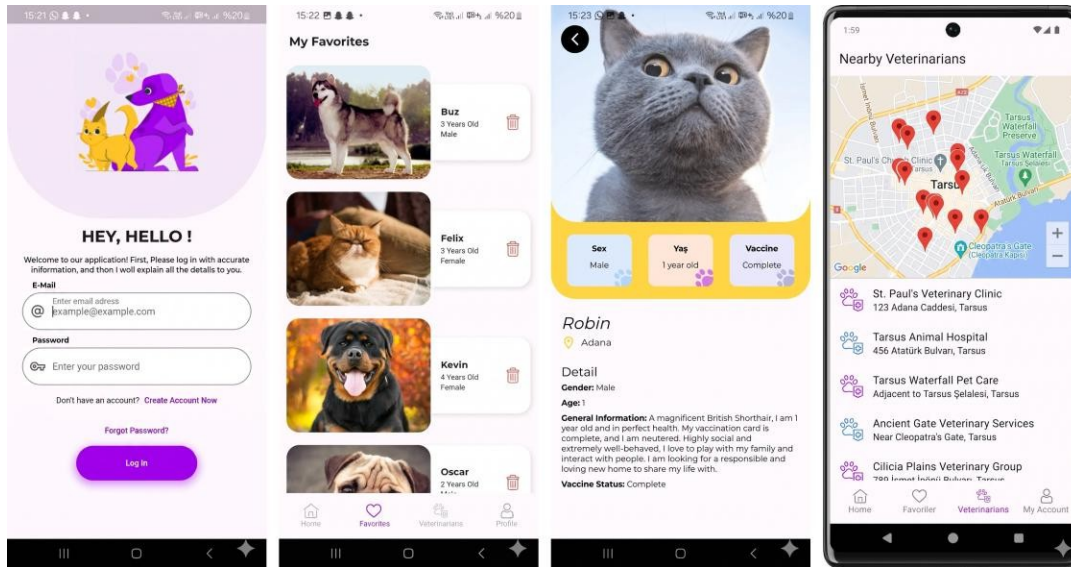


Figure 3. Principal Screen Interfaces of the PATILE Application

The authentication interface, situated on the far left of Figure 3, serves as the primary entry point and features secure email/password credential fields. The illustrative element in the upper section is strategically positioned to foster an emotional connection with the target audience of animal enthusiasts. Essential recovery and registration pathways, such as the 'Forgot Password' and 'Create Account' prompts, are integrated to ensure seamless user onboarding.

The 'My Favorites' dashboard, the second interface from the left, enables users to aggregate selected animal profiles into a personalized repository. This module utilizes a card-based layout- displaying each animal's photograph, name, age, and sex- to serve as a decision-support mechanism, allowing prospective adopters to revisit and compare candidates. The persistent four-tab navigation bar (Home, Favorites, Veterinarians, Profile) ensures intuitive access across the application's core modules.

The animal-detail page, the third interface, functions as the critical decision-making hub. The layout features a high-resolution hero image, followed by high-visibility data cards (sex, age, and vaccination status) optimized for rapid cognitive processing. The lower segment integrates the animal's name, geographical location, and comprehensive narrative data. This architectural choice directly mitigates the 'profile fragmentation' identified as a deficiency in contemporary applications in Section 3.1.

Finally, the nearby-veterinarians screen, on the far right of Figure 3, leverages the Google Maps API to display veterinary clinics in both map and list formats based on the user's real-time geolocation. By facilitating post-adoption healthcare access, this module transitions the application from a mere transactional tool into a holistic ecosystem that promotes sustainable animal welfare.

3.3. Test Results

The application underwent comprehensive functional and performance evaluations to validate its operational reliability. Table 2 summarizes the primary test scenarios executed, alongside their respective outcomes.

Table 2: *Application Test Results*

Test Category	Test Scenario	Expected Result	Observed Result	Status
Authentication	New user registration	Successful registration and redirection	Successful	✓
Authentication	Incorrect password entry	Display of error message	Successful	✓
Animal Listing	Display of all animals	Data retrieval from Firebase	Successful	✓
Animal Profile	Navigation to detail page	Profile information and visuals	Successful	✓
Filtering	Filtering by species and age	Filtered list	Successful	✓
Favorites	Adding an animal to favorites	Persistence in Firebase	Successful	✓
Feedback	Filling and submitting the form	Persistence in the database	Successful	✓
Map	Listing of nearby veterinarians	Location-based list	Successful	✓
Performance	Application launch time	< 3 seconds	~1.8 seconds	✓

All designated test scenarios were successfully validated, confirming the system’s operational integrity. The mean application launch time was recorded at approximately 1.8 seconds, a performance metric that remains substantially below the 3-second threshold cited in mobile usability literature [12]. This result indicates that PATILE provides a highly responsive user experience, effectively minimizing latency-induced friction during the initial user engagement.

3.4. Institutional Verification and Societal Impact

Beyond the delivery of a technical software output, this study underwent a rigorous multi-stakeholder institutional validation. Following a comprehensive review, the Information Technology and Press Department of the Municipality of Tarsus extended a formal collaboration proposal to integrate PATILE into the municipality’s 'Empati Platformu' (Empathy Platform) initiative.

The project's academic and practical significance was further recognized when it was selected—from a competitive pool of 104 projects—for presentation at the TÜBİTAK-supported R&D Project Marketplace

at Mersin University on 7 May 2024. Furthermore, on 5 June 2024, an outreach and awareness event was conducted for middle-school students at Tarsus Toros College to foster early-age animal welfare stewardship. Finally, to expand the project's nationwide influence, promotional materials were disseminated to municipal administrations across all 81 provinces of Türkiye, establishing a baseline for national scalability.

3.5. Assessment of Scientific Contributions

The original contributions of this study to the existing literature are categorized into three primary domains. First, while previous research—such as the work by More et al. [2], Malwe et al. [4], and Blancaflor et al. [6]—focused on specialized sub-problems like location-based matching or machine-learning-driven breed identification, PATILE introduces an integrated platform architecture that facilitates the adoption lifecycle from end to end. Second, the study presents a localized solution tailored to the linguistic requirements and specific bureaucratic frameworks of Türkiye, such as veterinary certification and municipal coordination. Third, the technology-transfer dimension was systematically operationalized through municipal partnerships, educational outreach, and the nationwide dissemination of project materials across all 81 provinces.

Despite these contributions, certain limitations remain. The application has not yet been released for public use on the Google Play Store, which has constrained the collection of longitudinal quantitative data regarding user behavior and actual adoption rates. Furthermore, user satisfaction was not quantified using standardized instruments, such as the ISO 25010 framework or the System Usability Scale (SUS). Addressing these methodological gaps in future research will provide more robust empirical evidence regarding the long-term efficacy of digital adoption platforms.

4. Conclusion

In this study, a Flutter and Firebase-based Android application was developed and presented, aimed at digitizing and optimizing adoption processes within animal shelters. By addressing the deficiencies identified in contemporary systems, PATILE bridges existing functional gaps through the integration of comprehensive animal profiles, multimodal media support, a streamlined application workflow, and dedicated educational modules.

Functional verification confirmed that the platform operates reliably across all primary operational scenarios, while the collaboration with the Municipality of Tarsus and the successful regional outreach events demonstrate a capacity for institutional and societal impact that transcends the project's technical specifications.

For future research, it is recommended that the application undergo a large-scale public release followed by a formal usability evaluation aligned with ISO 25010 standards. Furthermore, the integration of machine-learning-driven matching algorithms is proposed to enhance adopter-animal compatibility. In this context, YOLOv11-based detection studies provide a useful technical reference for possible image-based animal classification or profile-verification modules. IoT-supported feedback architectures may also be adapted to enable remote monitoring of adoption outcomes and post-adoption follow-up processes. In addition, adaptive

and optimization-oriented control studies indicate that dynamic system behavior can be improved through iterative testing and performance-based refinement. Finally, establishing an anonymized open-database infrastructure for shelter data could provide a critical empirical resource for animal welfare researchers and policymakers in Turkey.

6. Declaration

6.1 Study Limitations

This study was conducted with a relatively small user group consisting of university students and local residents. The application was tested exclusively on Android devices using synthetic shelter data, which may limit generalizability. Future studies should involve broader participant samples, real shelter datasets, and cross-platform testing.

6.2 Acknowledgements

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6.3 Funding source

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6.4 Competing Interests

There is no conflict of interest in this study.

6.5 Authors' Contributions

Kenan ERİN: Conceptualization, supervision, project administration, writing–review & editing.

Janberk ALTAY: Software development, data collection, writing–original draft.

Buse SARI: System testing, visualization, writing–original draft.

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