Date: November 21, 2024 Document Version: 1.0

CS491: Senior Design Project I
Project Specification Report

Group: T2443

yodai

Yasemin AKIN 22101782	Deniz Can ÖZDEMİR 22003854	Oğulcan KARAKOLLUKÇU 21802642	Alphan TULUKCU 22003500	İlhami ULUĞTÜRKKAN 22102546

Table of Contents

1. Introduction

After the recent legislation in Turkey that mandates the removal of stray animals from public places and their placement in shelters, it is urgent to enhance the adoption process to avoid overcrowding and euthanasia risks for these animals. In July 2024, this law was passed to address public safety concerns, but it has proved to be a source of tremendous difficulty for animal welfare organizations [1]. Our goal is to build a new platform to simplify adoption. Our goal is to strengthen the bond between potential adopters and the animals in need by providing comprehensive animal profiles, including health records and behavioral traits, personalized care recommendations, and most importantly, a sophisticated personalized stray animal recommendation system. The platform will also provide adoption guidance and post-adoption support. Beyond providing a solution to the urgent problems created by the new law, this initiative also serves to support the long-term health of stray animals in Turkey through the promotion of sustainable adoptions and strained shelter resources. This report aims to provide more detailed information about the project's vision, mission, scope, and content by including detailed information about the project's specifications.

1.1 Description

Assisted by Kurtaran Ev, a well-known Istanbul, Türkiye rescue shelter, this project aims to completely transform how animals are adopted by creating a revolutionary platform. The platform aims to solve long-standing inefficiencies in current systems by leveraging advanced technologies such as image recognition, artificial intelligence (AI), and automated matching algorithms. Challenges also include no streamlined matching processes and incomplete or inaccessible animal profiles. This platform is looking to introduce a more technological and automated approach to offer an effective and user-friendly solution for prospective owners and shelter animals alike.

The platform’s core is to simplify and optimize the process of animals matching potential adopters. It does this by creating in-depth and comprehensive animal profiles, including health records, vaccination histories, behavioral assessments, and personalized care recommendations. These features give the adopters a better understanding of their potential pets’ needs so they can make informed decisions and be better prepared to adopt a pet. A matching algorithm adds to this by ensuring adopters are matched to animals that fit their lifestyles, preferences, and capabilities, making for a more compatible and successful adoption.

Once past the initial adoption of the platform, the support features are robust enough to ensure the long-term success of pet ownership. This initiative is anchored around a sophisticated AI-driven chatbot that assists at all stages of adoption, pre-adoption, adoption, and post-adoption. This chatbot is able to answer queries, help guide adoption procedures, and provide ongoing support for training and veterinary care. By bringing together these pieces, the platform builds a supportive ecosystem for animals and their new families, facilitating a smooth transition and intense bonds.

The overall goal here is to drive meaningful change in adoption that has the potential to be sustainable and energizing. The platform reduces the risk of returned adoptions. It addresses gaps in existing systems, not only reducing the burden on overcrowded shelters but also advancing the larger mission of animal welfare. This initiative aims to change that future by taking an innovative approach to create a future where animals in rescue shelters can find loving, permanent homes and their new adopters are equipped with the tools and knowledge to properly care for them properly [2].

1.2 High-Level System Architecture and Components of Proposed Solution

KurtaranAI's architecture is designed for scalability, reliability, and cross-platform compatibility. The user interface will be built with React Native Expo, ensuring seamless operation across multiple platforms. The backend will use Django as the framework for application logic, with an API gateway managing secure and efficient communication between the front end and server.

PostgreSQL will serve as the primary database system for managing relational and vector data, ensuring robust and reliable storage. Firebase will handle image data storage, providing scalability and high availability for multimedia content. For system monitoring, Prometheus will collect metrics, while Grafana will visualize them to support performance and health tracking.

Initially, a local machine will serve as the server, with plans to scale to a dedicated or cloud-based solution as the project grows. This architecture is represented through a subsystem decomposition diagram that outlines the integration of components into a cohesive, user-friendly system.

1.2.1 Subsystem Decomposition

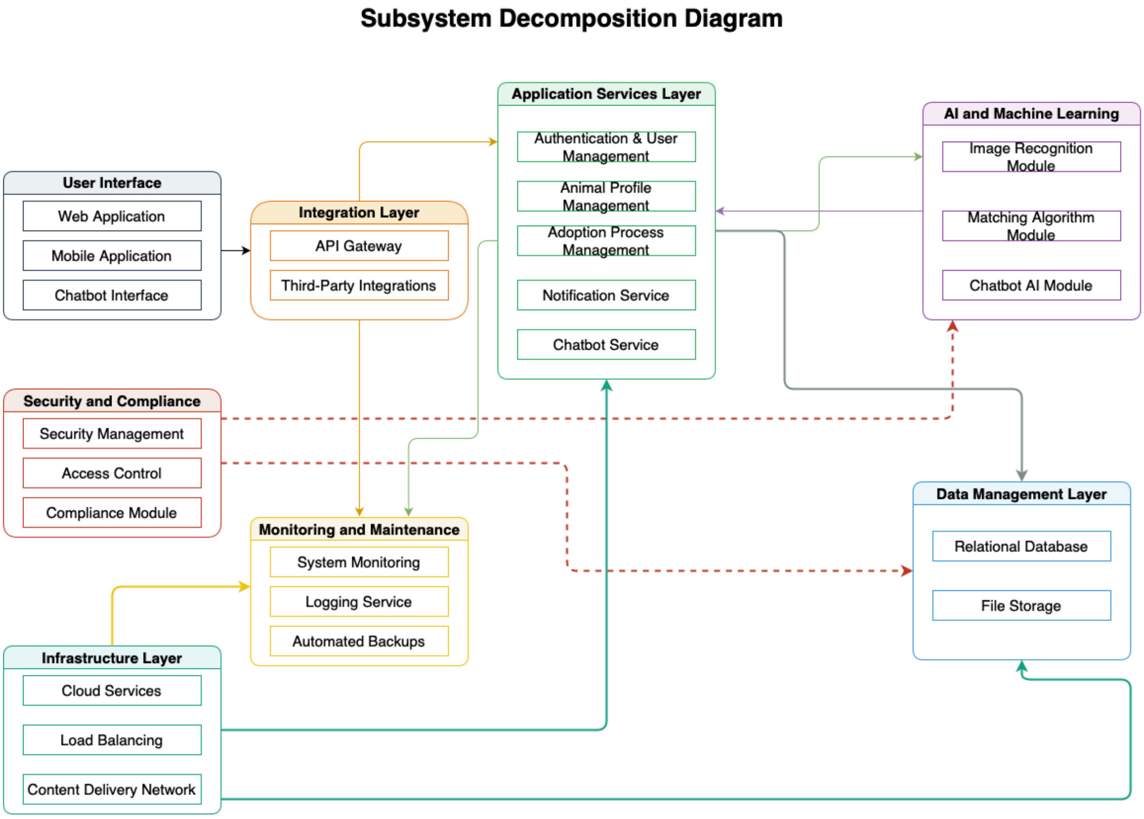


Figure 1: Subsystem Decomposition Diagram

1.2.2 Subsystem Explanations of Core Components

1.2.2.1 Chatbot AI Module

This module will help users throughout the adoption lifecycle, from pre-adoption to adoption and post-adoption. The chatbot will be able to answer quick queries, guide users through adoption processes, and provide continued support for training and veterinary care. It'll use frameworks like LangChain and LangGraph, and will connect to OpenAI's pre-trained language models via an API gateway at the backend. Self-refinement and Retrieval Augmented Generation (RAG) techniques will be used by the chatbot to ensure security and correctness, dynamically access and provide accurate information while maintaining data integrity and upholding privacy regulations.

1.2.2.2 Matching Algorithm Module

The user-animal matching system will be based on traditional ranking methods. We will rank animals according to user parameters, which are determined by Kurtaran Ev and other rescue shelters. Our training dataset for this model will contain previous adoption successes and failures. We will use libraries such as numpy and pandas for data manipulation and computing and sklearn or rank_bm25 to calculate various matching scores between animals and users. We are planning to calculate various scores with different weights and calculate the final matching scores.

1.2.2.3 User Interface Module

The client side will be a cross-platform application that supports web, IOS, and Android systems. React Native will be used as a framework to develop a cross-platform system. Moreover, Expo will be integrated with React Native to simplify the development process by providing tools, services, and libraries that enhance the app's performance and compatibility. Expo's pre-configured environment will reduce setup time and allow easier device testing.

1.2.2.4 Image Recognition Module

To identify and classify breeds of stray cats and dogs from their images, this module uses a pre-trained CNN deep learning model. It analyzes the uploaded photos, and based on that, it recognizes the breed information and uses that information to update animal profiles on the platform. By automating the breed identification process, the module increases efficiency for shelter staff and helps potential adopters know more about the breed.

1.3 Constraints

When developing a project of this scale, you need to think about the constraints that may prevent the project from being successful. There are many factors, including technical, budgetary, and ethical constraints, that affect the design, development, and implementation process. The goal here is to find and address these constraints early and produce a solution that is realistic and effective while still allowing for some innovation, while still meeting economic and ethical boundaries.

1.3.1 Implementation Constraints

1.3.1.1 Data Collection

Data collection is one of our project's most difficult tasks. It is challenging to collect comprehensive and reliable data because many rescue shelters store animal information using outdated or disorganized systems. For instance, some shelters may categorize animals using completely different systems, while others may lack behavior assessments or health data. This implies that before our platform can use the data efficiently, we will need to spend time standardizing it.

1.3.1.2 Data Privacy

Even if there are digital records present, legal agreements with the establishments may be necessary to share data with the platform in order to guarantee compliance with national and international privacy rules. The implementation of secure protocols and encryption techniques is necessary to protect sensitive data during transmission and storage, which adds even more complexity.

1.3.1.3 Skill Gaps

Our team has experience in programming but creating a platform like this puts us in territories we are still learning and testing. Although we have a clear idea about what artificial intelligence (AI) and machine learning (ML) are, it is a very big step to move to creating and optimizing convolutional neural network (CNN) models for practical applications. Furthermore, creating an AI-supported chatbot based on large language models (LLMs) (which are comparatively unknown to us) entails additional challenges. Designing a cross-platform mobile application that will be scalable and fault-tolerant, designing a microservice architecture, and creating a machine learning-based recommendation system are challenging tasks. All of these elements combined accentuate the lack of specific knowledge and constantly encourage us to extend and develop our knowledge for the sake of the project. This steep learning curve could slow down our development process because it will take quite some time before we master the use of the software.

1.3.1.4 Technology Limitations

While it is our intention to use complex models such as CNNs for image recognition and machine/deep learning algorithms for matching, we are constrained by the computational resources which are available to us. These models are often complex to compute and demand large resources, which can hinder the performance of the platform, or even freeze it during operations in real-time. Balancing the complexity of these algorithms with the need for a smooth user experience is another major hurdle. On top of that, we are working within the limitations of our existing knowledge and tools, which means some compromises may have to be made to meet our project deadlines.

1.3.1.5 Time Constraints

We have limited time to implement this project. Approximately one academic year. We need to bring the project from the planning and research phase to the implementation, testing, and launching phases within this year. Every phase of the project is time-intensive, especially training and refining ML models. Since we have limited time, if any of these phases are disrupted, it will seriously affect the next phase and reduce its efficiency, so it is very important for us to try to do everything within the planned time.

1.3.1.6 Scalability and Maintenance Constraints

We are currently developing the platform to serve a single shelter or a small user base, but if it becomes successful, it will need to grow. This involves handling far more datasets, more adopters, and more shelters. A major difficulty is designing a system that meets our present requirements while allowing for future scalability. On top of that, the platform will require ongoing updates and maintenance, like adding features or integrating new technologies, which goes beyond what we can realistically achieve within the scope of this project.

1.3.2 Economic Constraints

1.3.2.1 Budget for Resources

Since we are operating under extremely limited resources, cost is an overriding consideration that has to inform all our choices. While hosting on cloud platforms like AWS and Google Cloud has good capabilities for hosting and processing data it can be expensive especially when dealing with large datasets or performing computational intense processes. We want to employ a great number of open-source and free tools to reduce costs. Although these tools are cost-saving, their capabilities and support can be quite reduced, so we should always take time and decide on the most efficient. Another important consideration is that training most machine learning models requires having access to specialized hardware like GPUs which we don’t possess. All these resources can be acquired through cloud services, but in cases where the training period is extended, the expenses concerning the related services may increase significantly. Further, real-time processes like image recognition or dynamic matching need to compute fast and accurately, which may prove to be expensive and add to our cost. Optimizing the costs and performance is going to be a strategic issue that will need a proper approach towards resource management.

1.3.2.2 Adoption Motives

Our platform would be more attractive if we offered adoption-promoting incentives, such as first veterinarian examinations or discounted pet supplies, but they are expensive. We probably will not be able to incorporate such features in our initial edition without collaborations or sponsorships. We will need to look for innovative, low-cost solutions to make the adoption process rewarding for users.

1.3.3 Ethical Constraints

1.3.3.1 Bias in Algorithms

Potential bias in our AI models is one issue that really worries us. Our matching technology may unfairly prioritize certain animals, making it more difficult for other animals to find homes, if the training data we utilize is skewed, for instance, favoring particular breeds or appearances. For animals that are already at a disadvantage due to disabilities or less "popular" characteristics, this is particularly troublesome. In order to prevent these biases from being reinforced, we will need to carefully assess and modify our algorithms.

1.3.3.2 Animal Welfare

Ensuring animal welfare is central to our project, but it's also one of the hardest things to guarantee. If the platform makes it too easy to adopt an animal without proper vetting, it could lead to impulsive decisions and, eventually, returned adoptions. This is not only stressful for the animals but also undermines our goal of creating lasting bonds between adopters and their pets. We will need to include features that educate adopters about the responsibilities of pet ownership and encourage thoughtful decisions.

1.3.3.3 Adopter Privacy

The other important ethical issue involves the privacy of the adopter. We will be gathering personal information, and data preferences, which makes the platform vulnerable to data breaches. Implementing strong encryption and secure storage methods is essential, but it also adds complexity to our development process. We also need to ensure transparency by giving users control over their data, like the ability to review or delete it.

1.3.3.4 Fair Use of AI

Our chatbot is designed to provide ongoing support to adopters, but relying too much on automation can lead to problems. For example, if the chatbot gives generic or incorrect advice about training or healthcare, it could frustrate users or even harm the animals. We will need to ensure the chatbot is well-trained and capable of escalating complex queries to real experts.

1.3.3.5 Cultural Sensitivities

Adoption practices and attitudes toward animals vary widely across cultures, and we need to account for this in our design. For instance, in some communities, animals might be valued more for their utility (like guarding) than companionship. While our platform should promote responsible adoption, it also needs to be flexible enough to accommodate these cultural differences without alienating users. This will require thoughtful language choices and inclusive design.

1.4 Professional and Ethical Issues

It is one of our top priorities to ensure that no users or animals are harmed due to the usage of our application. Due to the new stray animal laws coming into force in our country, stray animals need to be adopted faster. It is essential that we take certain precautions to ensure that our animal friends are adopted quickly but safely. In order to ensure the safety of animals, only shelters and rescue shelters will be allowed to share adoptable animals. In this way, we prevented attempts to deceive users by entering incorrect or incomplete animal information. One of the other reasons we take this precaution is that if everyone shares stray animals, we may cause users who may want to harm the animals to reach the location of these animals. Another reason is to prevent ordinary users from contacting other users who want to adopt and then trying to earn income from animal adoptions. Since we do not want our animal friends to be adopted only according to their species and their species' characteristics, we decided not to share the species of our animal friends with users. We will use an unbiased matching algorithm that only takes into account the needs of the animals and the information of people who want to adopt them, in order to treat all animals equally, preventing animals from being highlighted based on their species or any other characteristics.

1.5 Standards

In this project, it is important to follow certain standards in order to attain the goals of reliability, scalability and ethical and technical acceptability. The implementation of our solution will be done in accordance with the international and regional standards of software development, data protection and artificial intelligence to make sure that the platform complies with the highest quality standards. In particular, we will try to implement an information security management system based on the ISO/IEC 27001 standard and guarantee the confidentiality of adopter and shelter's data during storage and transferring. Also, we want to follow IEEE 12207 standard for software lifecycle processes so that there is consistency within the processes that will be used throughout the development of the project. Regarding data protection, GDPR for the users' data will be followed so that the personal data is not misused and the process is more transparent.

One of the key distinctive features of our work will be the establishment of the Pet Adoption Benchmark, which will serve as a new evaluation and improvement model of animal adoption procedures. This benchmark will then be useful for the shelters and organizations around the world in the assessment of their operations. By adhering to the above standards, we will aim to create a creative and responsible platform to meet the challenges in animal adoption.

2. Design Requirements

2.1. Functional Requirements

2.1.1 User Registration and Authentication

Only adoption candidates will register for the system by themselves. They are asked to give some personal information such as their name, surname, age, address, etc., some of which will be crucial for adoption eligibility. Therefore, we want each user to verify the information they give. Also, we want them to authenticate their account with some methods.

2.1.2 Deep Learning-Based Visual Breed Classification

The aim is to implement a model that classifies the breed of dogs and cats from the given images. To achieve this, 3 different models will be trained on a specific dataset and compare their evaluation metrics to choose the one with the highest standards: one simple Convolutional Neural Network (CNN), one MobileNet CNN architecture will be trained from scratch, and one pre-trained CNN-based (ResNet50 or VGG16) model leveraging transfer learning will be trained from scratch.

2.1.3 Recommendation System for Sustainable and Accurate Adoptions

This functionality is the central part of the KurtaranAI. We did market research about similar applications, and we realized that no system uses a recommendation system for available animals. Therefore, we will focus on developing an efficient recommendation algorithm so that adoption candidates will see the animals that are convenient for their and the animals' lives. To develop this algorithm, we will use the metrics that have been already used by rescue shelters manually. Moreover, we want to make this system dynamic so that the previous decisions of the adoption candidates will also affect the next recommendations. For this purpose, we plan to use both collaborative and content-based filtering to build a hybrid system. Leveraging user data such as preferences, behavioral data, and lifestyle information gathered from pre-requested forms and user activities and animal data such as breed, age, size, temperament, and special needs (like medical conditions), we plan to practice feature extraction, similarity measuring, matrix factorization, etc.

2.1.4 Quiz System

The aim is to understand which candidates are more eligible to adopt an animal. To understand this, we will give some mandatory quizzes prepared by professionals. Having solved all the quizzes, candidates will see the adoption portal if they are eligible for adoption. If not eligible, the plan is to direct them to a temporary adoption domain. We may use additional quizzes before the adoption process is done.

2.1.5 Chatbot Support (for Q/A)

The other crucial part of the KurtaranAI* is the chat assistant. Kurtaran Ev -our pilot shelter- observed that there are numerous questions about animal care, health, training, etc. on their Instagram DM. To inform people and decrease the workload about messages, we will develop an LLM (Large Language Model) agent for question/answer for everyone. Moreover, some approved chats will be visible to everyone so that they can be used as an external information source. By feeding the LLM with user data, the end plan is to develop personalized veterinary assistance for users to accompany them through their adoption journey.

2.1.7 Notifications and Alerts

The aim is to notify users about the progress of their adoption processes. By nature of the process, some steps require manual approvals from the rescue shelter attendants, we plan to update users on these advancements as the process continues. Additionally, for the post-adoption process, since the new adopters will be under the surveillance of the rescue shelter attendants, they will be required to upload or send some evidence to show that the process is being carried out well. During this process, alerts can be set for users to remind them of these checkpoints.

2.2. Non-Functional Requirements

2.2.1 Usability

The platform should be easy to navigate for users with minimal technical skills since the target groups' ages of rescue shelters vary on a large scale. Also, both adopting a pet and using a mobile app can be complicated for most of the users. The app should inform and navigate users. Ensure clear visual cues (e.g., buttons, links, tooltips) to guide users through the adoption process.

2.2.2 Reliability

The most crucial parts of the project are ChatBot and the matching algorithm between animals and users. These features must be reliable and dynamic to satisfy both animals' and users' needs. The chatbot feature of the application must have a 90% or higher correct response rate based on our frequent questions and answers dataset obtained by Kurtaran Ev's forum. Also, we are planning to have an approximately 80% precision rate for retrieving relevant animals for users concerning our dataset which was obtained by Kurtaran Ev's adoption archive. Also, we attach great importance to both features' robustness and dynamicity.

2.2.3 Performance

The app will include a lot of videos and images. While retrieving them from the database, we must wait less than 3 seconds. Use lazy loading for images and animations to improve page speed.

2.2.4 Supportability

The app will be cross-platform since the target users' platform usage is distributed nearly equally. Also, since this project is a senior design project, detailed documentation of the implementation and the design of the application will be documented clearly. Finally, with the feedback system of the application, bugs and issues can be prioritized and solved.

2.2.5 Scalability

The project has the potential to be used by thousands of people, necessitating a platform that can scale seamlessly to support growing demands. It must efficiently handle simultaneous access from multiple users without performance degradation, ensuring smooth interactions such as concurrent searches, chats, and profile views.

2.2.6 Sustainability

In order to be cost effective in terms of sustainability, we will choose servers and databases that will meet our needs but are as free or low-priced as possible. As time progresses, we plan to continue in this way until we need a server that can manage a larger network, and then transfer it to paid servers.

3. Feasibility Discussions

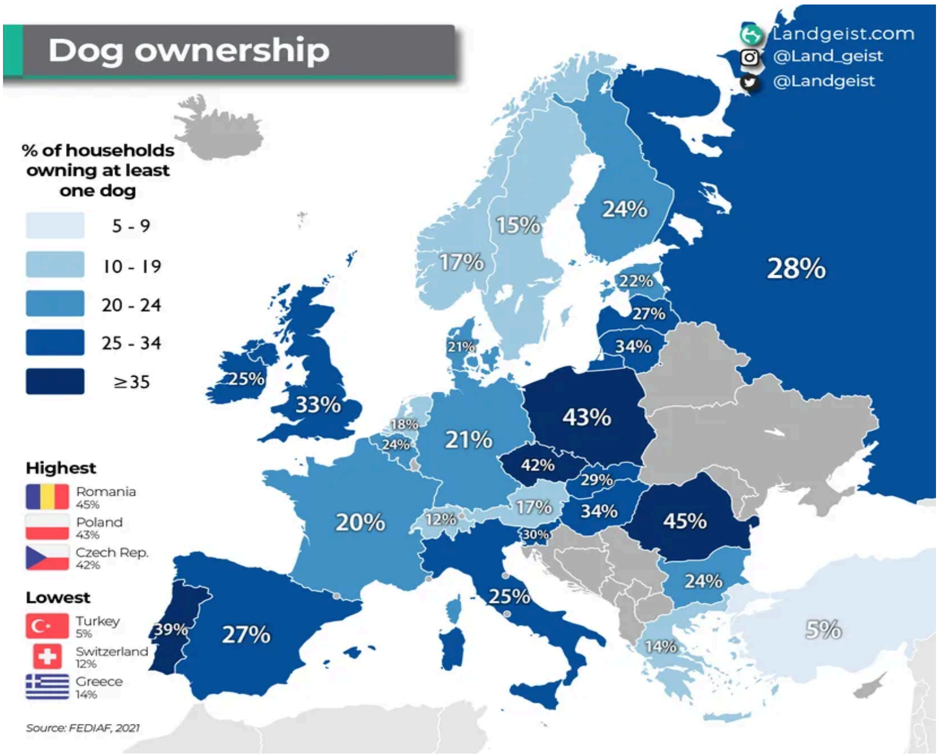
3.1 Market & Competitive Analysis

For this section, similar applications were analyzed in the mobile app markets. One example is SemtPati, which was developed by Koç System for the Istanbul Municipality. It has some similar features, such as adopting dogs and cats from shelters and monitoring animal features such as image, age, breed, etc. However, it works as an open market. It does not use any recommendation or matching system. Therefore, anyone can apply for any stray animals. On the other hand, the main purpose of the KurtaranAI is to optimize the adoption process with an advanced recommendation system. Apart from Semtpati, many applications are made for this purpose, such as Mutlu Patiler, Petner, and Patievi. Based on these applications and the consultancy we received from the people we talked to and Kurtaran Ev officials while trying to develop the idea of this application, it is understood that there is a great demand in this field.

3.2 Academic Analysis

Türkiye faces a severe challenge with its stray dog population, estimated at around 4 million animals [3]. Public safety concerns, including incidents of dog attacks and the spread of diseases such as rabies, have led to the Turkish government's July 2024 policy mandating the removal of stray dogs from streets and placing them in shelters. However, this policy has sparked significant controversy, with critics highlighting potential issues such as overcrowded shelters and increased euthanasia rates [4].

Interestingly, Türkiye's stray dog problem is not primarily due to the sheer number of dogs but rather the remarkably low rate of dog ownership. As highlighted in the dog ownership map below, only 5% of Turkish households own a dog, placing Türkiye at the lowest rate in Europe. In contrast, countries like Romania (45%), Poland (43%), and the Czech Republic (42%) have significantly higher ownership rates. If Türkiye's dog adoption rates matched Romania's, the problem of stray dogs would be greatly mitigated, as most dogs would find homes rather than roaming the streets. This underscores that the real challenge lies in the cultural and logistical barriers to adoption, not the overall number of dogs [5].



Source: FEDIAF, 2021

Figure 1: Percentage of households owning at least one dog in European Countries [6].

AI-driven chatbots and large language models (LLMs) like GPT hold immense potential for enhancing pet care and support throughout the adoption lifecycle [7]. Chatbots provide instant responses to questions from potential adopters, reducing staff workload while ensuring that all inquiries are addressed promptly [8]. During the post-adoption phase, chatbots can deliver customized advice on training, diet, and healthcare based on the specific needs of the pet and the adopter's preferences [7]. Additionally, adoption processes can benefit significantly from AI-powered matching algorithms, which are already widely successful in applications like Tinder and other recommendation-based platforms [9], [10]. These algorithms analyze user preferences, behaviors, and requirements to identify the most compatible matches [11]. However, it should be noted that the matching algorithm we will use will make the best match by taking into account not only the wishes and preferences of the adopters but also animals' happiness according to their characteristics.

As shown through the research, Türkiye's stray dog issue presents a complex challenge requiring innovative solutions. By fostering responsible ownership and enhancing the adoption process, these technologies can play a critical role in alleviating the stray dog problem while promoting animal welfare.

4. Glossary

API Gateway: A server that acts as an API front-end, handling client requests, routing them to appropriate backend services, and managing tasks such as authentication, rate limiting, and analytics [12].

Artificial Intelligence (AI): The simulation of human intelligence processes by machines, especially computer systems, enabling them to perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation [12].

Chatbot: A software application designed to simulate human conversation, allowing users to interact with digital devices as if they were communicating with a real person [12].

Convolutional Neural Network (CNN): A class of deep neural networks, most commonly applied to analyzing visual imagery, that uses a mathematical operation called convolution to process data in a hierarchical manner [13].

Cross-Platform Application: Software designed to operate on multiple computing platforms, such as Windows, macOS, Linux, iOS, and Android, without requiring separate codebases for each [12].

Data Privacy: The practice of handling and processing data in a manner that ensures the confidentiality and protection of personal information from unauthorized access or disclosure [12].

Deep Learning: A subset of machine learning involving neural networks with many layers (deep neural networks) that can learn and make intelligent decisions on their own by analyzing large amounts of data [12].

Django: A high-level Python web framework that encourages rapid development and clean, pragmatic design, used for building web applications [13].

Firebase: A platform developed by Google for creating mobile and web applications, offering services such as real-time databases, authentication, and hosting [13].

Front-End Application: The part of a software application that interacts directly with the user, encompassing the user interface and user experience aspects [12].

LangChain: A framework for developing applications powered by language models, facilitating the integration of large language models with external data sources and APIs [13].

LangGraph: A tool or framework designed to enhance the capabilities of language models by structuring and managing their interactions with various data sources and processes [13].

Large Language Model (LLM): A type of artificial intelligence model trained on vast amounts of text data to understand and generate human-like language [12].

Machine Learning (ML): A branch of artificial intelligence that involves the development of algorithms and statistical models enabling computers to perform tasks without explicit instructions, relying on patterns and inference instead [12].

MobileNet: A class of efficient models designed for mobile and embedded vision applications, optimized for performance and low computational cost [13].

Numpy: A fundamental package for scientific computing with Python, providing support for arrays, matrices, and a collection of mathematical functions to operate on these data structures [12].

OpenAI: An artificial intelligence research organization focused on developing and promoting friendly AI for the benefit of humanity [13].

PostgreSQL: An open-source, object-relational database system known for its robustness, extensibility, and standards compliance [12].

Prometheus: An open-source systems monitoring and alerting toolkit, particularly suited for monitoring dynamic cloud environments [13].

React Native: An open-source framework developed by Facebook for building native mobile applications using JavaScript and React [13].

Recommendation System: A subclass of information filtering systems that seek to predict the ‘rating’ or ‘preference’ a user would give to an item, commonly used in applications like online shopping and streaming services [12].

ResNet50: A 50-layer deep convolutional neural network known for its performance in image recognition tasks, part of the Residual Networks (ResNet) family [13].

Retrieval Augmented Generation (RAG): A technique that combines retrieval-based and generation-based methods in natural language processing to produce more accurate and contextually relevant responses [12].

Scikit-learn (sklearn): An open-source machine learning library for Python, offering simple and efficient tools for data analysis and modeling [13].

Transfer Learning: A machine learning technique where a model developed for a particular task is reused as the starting point for a model on a second task, leveraging prior knowledge to improve learning efficiency [12].

Vector Data: Data represented in the form of vectors, often used in machine learning and spatial analysis to represent features such as points, lines, and polygons [12].

VGG16: A convolutional neural network model known for its simplicity and effectiveness in image recognition tasks, consisting of 16 layers [13].

5. References

[1] “Turkey Approves Law to Remove Stray Dogs from Streets. Opposition Vows to Fight the ‘Massacre Law’,” AP News. [Online]. Available: https://apnews.com/article/turkish-parliament-approves-law-stray-dogs-a5870dbff7066f0d11f34758b39bcf5f?utm_source=chatgpt.com. [Accessed: November 20, 2024].

[2] "YOD-AI Documentation," YOD-AI. [Online]. Available: https://yod-ai.github.io/yodai/#. [Accessed: November 19, 2024].

[3] BBC Türkçe, “Türkiye’nin sahipsiz köpek sorunu: 4 milyon köpek olduğu tahmin ediliyor,” [Online]. Available: https://www.bbc.com/turkce/articles/crg7y137pjzo. [Accessed: Nov. 21, 2024].

[4] AP News, “Turkey plans to regulate a large stray dog population,” [Online]. Available: https://apnews.com/article/turkey-stray-dogs-shelters-animal-rights-66eff47e6a99f21041589c5786d89bcc. [Accessed: Nov. 21, 2024].

[5] Evrim Ağacı, “Türkiye’de Sokak Köpeği Sorunu Nasıl Çözülür?,” [Online]. Available: https://evrimagaci.org/turkiyede-sokak-kopegi-sorunu-nasil-cozulur-17769. [Accessed: Nov. 21, 2024].

[6] Landgeist, “Dog ownership in Europe,” Mar. 2023. [Online]. Available: https://landgeist.com/wp-content/uploads/2023/03/europe-dog-ownership.png. [Accessed: Nov. 21, 2024].

[7] A. E. Villalobos and S. Lee, “Applications of AI in veterinary and animal welfare,” *Veterinary Medicine and Science*, 2023. [Online]. Available: https://onlinelibrary.wiley.com/doi/full/10.1002/vms3.1464. [Accessed: Nov. 21, 2024].

[8] T. K. Vashishth, V. Sharma, K. K. Sharma, B. Kumar, A. Kumar, and R. Panwar, “Artificial Intelligence (AI)-Powered Chatbots,” in *Artificial Intelligence in Modern Healthcare Applications*, 1st ed., 2023. [Online]. Available: https://www.taylorfrancis.com/chapters/edit/10.4324/9781003488248-15. [Accessed: Nov. 21, 2024].

[9] S. Gupta et al., “Recommendation Algorithms in Modern Applications,” *IEEE Transactions on Consumer Electronics*, 2023. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10489819. [Accessed: Nov. 21, 2024].

[10] Tinder, “Powering Tinder: The Method Behind Our Matching,” [Online]. Available: https://www.help.tinder.com/hc/en-us/articles/7606685697037-Powering-Tinder-The-Method-Behind-Our-Matching. [Accessed: Nov. 21, 2024].

[11] P. Lewis et al., “User-Centric Design in AI Matching Algorithms,” *Behaviour & Information Technology*, 2023. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/0144929X.2023.2196579. [Accessed: Nov. 21, 2024].

[12] IBM, “What Is an API Gateway?” [Online]. Available: https://www.ibm.com. [Accessed: November 21, 2024].

[13] freeCodeCamp, “Learn to Code — For Free.” [Online]. Available: https://www.freecodecamp.org/. [Accessed: November 19, 2024].