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CS-499-19649-M01 Computer Science Capstone 2025

7 Final Project: Enhancement Two: Algorithms and Data Structure

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This document serves as the final submission for my capstone project, where I will present the code pertinent to my CS 499 final project. The focus of my CS 340 Client/Server development project revolves around improvements made to the second section of the codebase, which pertains to Algorithms and Data Structures. I have designed an engaging and fully operational web-based training dashboard for an animal rescue organization, Grazioso Salvare to identifying dogs that can be trained for their search-and-rescue programs. By leveraging existing data from animal shelters in Austin, GS aims to pinpoint and categorize the available dogs. This project is a full stack application were Model, View, and Controller development patterns were used to create an interactive web-based dashboard.

In this project, animal information will be accessible through a database for users to use. An animal database allows the creation, reading, updating, and deleting of animals from the database, also known as CRUD.

As in the original project, the Animal Shelter class, It is a monolithic architecture which lacks flexibility and scalability because it is based on one tightly coupled codebase. If you want to modify or change one function, you must modify the whole application. The process is time-consuming and resource intensive.

A screenshot of a computer program

AI-generated content may be incorrect.

I have enhanced the code into smaller, independent services and have created microservices for each CRUD operations.. This will make each service independent and deployable separately. It is best to break up services into smaller, reusable, and maintainable units, such as modules, functions, and classes, in order to ensure that they can all be deployed separately. Work is still in progress and using methods that also allow us to access individual elements directly. This modular approach to software design loosens the coupling between components, enhancing flexibility and manageability throughout development.

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When accessed via a GET request, it fetches product data from the database. If successful, it processes the retrieved data, extracts details, and returns the information in a JSON format. In case of errors or no available data, it responds with an appropriate error message and status code.

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I have ensured that I apply the necessary logic to process user input based on the microservice's functionality and return a response to the user, which may include the processed outcome. I have also confirmed that the microservice accurately manages user input and generates the anticipated results. Therefore, I have considered security precautions, such as authentication and authorization, to safeguard your microservices and manage user data responsibly.

A screen shot of a computer program

AI-generated content may be incorrect.

Dashboard: The interactive table also has a pie and bar chart that changes based on the results displayed.

A screenshot of a computer

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A screenshot of a graph

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Since the animal class includes a variety of data types, it is more logical for dynamic data and applications requiring frequent changes to employ a dynamic data type for complex applications. In my view, implementing advanced list operations and algorithms allows for effective management of intricate data structures and the provision of efficient solutions. Therefore, I have utilized advanced techniques such as sorting, report generation, filtering, and searching to efficiently organize data for different computational tasks, ensuring flexibility, user-friendliness, and built-in features. With this improvement, lists can contain elements of various data types, and their size can adjust dynamically, which facilitates the easy addition and removal of items. Instead of constantly querying the database, I can keep data in lists within the application’s memory to conserve time and lessen the load on the server.

A screenshot of a computer code

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Through this enhancement, I have given exposure to designing and implementing MongoDB databases, querying data effectively, and exploring and manipulating data using Python and the Jupyter environment. In addition, this project establishes user authentication for administrators and users, and access data via a MongoDB database, thereby gaining more hands-on experience in data modeling, indexing, and other advanced MongoDB concepts.

Authentication and authorization of a user are managed based on user credentials, and user interaction with modules and actions are accountable for CRUD operations. Through this project, I have modeled data effectively to optimize performance and create efficient queries.

A screenshot of a computer program

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Currently, the application is modular enough. Modules are separated from the core codebase rather than being integrated into it, which makes the codebase more readable and easier to maintain. This project uses MongoDB as a database. Dash Plotly and Dash Leaflet comprise the view layer, and Python using Pymongo makes up the controller layer.

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Furthermore, I have produced reports by gathering, examining, and displaying information in an organized and comprehensible way. This approach significantly enhances the data analysis process, enabling me to create professional reports that clearly convey my insights. The source code is categorized into classes and methods according to their functionality and behavior. I demonstrate engineering principles among various classes and methods using arguments, parameters, and variables.

A screen shot of a computer program

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From the screenshot, you can see that as I entered incorrect details about the color of the animal. It throwed me an error saying that this animal was not found. By incorporating input validation and exception handling, I have improved both data security and accessibility in my code and database. By verifying user inputs and anticipating possible errors, I have prevented malicious data from accessing the system, safeguarded sensitive information (such as account details), and ensured seamless operation for all users.

This artifact has been improved in a way that aligns with the course outcomes I aimed to achieve.

Course Outcome 3: "Design and evaluate computing solutions that solve a given problem using algorithmic principles and computer science practices and standards appropriate to its solution while managing the trade-offs involved in design choices."

Through these improvements in the code, I have demonstrated my ability to create efficient solutions and have refined the Animal Shelter class's data structure and algorithms based on algorithmic principles. I have also shown my ability to make design trade-offs, such as utilizing advanced algorithm operations with List, which will enhance data access speed and facilitate operations such as Sorting, Searching, Filtering etc speeding up data retrieval leading to improved performance.

[Course Outcomes: 4]: Demonstrate an ability to use well-founded and innovative techniques, skills, and tools in computing practices for the purpose of implementing computer solutions that deliver value and accomplish industry-specific goals.

I have also demonstrated my ability to use well-founded and innovative techniques, skills, and tools in computing practices to implement computer solutions that deliver value and accomplish industry-specific goals, by selecting data structures and algorithms in a creative manner to enhance the system's value and performance. I have optimized system performance and value by choosing the right data structure for organizing data that can significantly impact efficiency and improve user experience. Additionally, this enhancement also benefits the system in design optimization include reducing latency, improving throughput, ensuring scalability, and maintaining robustness. The aim of these actions is to showcase our capacity to utilize established and creative methods, expertise, and resources to build in-demand computer solutions that provide value and achieve industry-specific objectives. It is possible to enhance the user experience by applying these principles and enhancements to code apps, making them more efficient, performant, and scalable and users can continue to interact with the application without experiencing slowdowns or errors, even during peak usage.

[Course Outcome 5]: Develop a security mindset that anticipates adversarial exploits in software architecture and designs to expose potential vulnerabilities.

I have also developed a security mindset that anticipates adversarial exploits in software architecture and designs to expose potential vulnerabilities. By applying data validation and data sanitization measures, I ensured that data would be protected against various injection attacks like SQL injection or Cross-Site Scripting, which can result in unauthorized access to data, unintended alterations, or the execution of harmful code. I have also taken steps to sanitize user inputs to prevent the inclusion of potentially harmful scripts in both the code and the database, thus securing that user-generated content is displayed securely

**Reflection, Challenges and Lessons Learned:**

The project's development and enhancement were highly adaptable and engaging due to MongoDB and Jupyter Notebooks. I realized the significance of breaking the complex code into smaller, more manageable components. This method makes the task easier and more feasible. Although modeling, querying, and optimizing data presented challenges, the experience provided valuable lessons that greatly improved my skills and comprehension in these fields. It offered me a meaningful opportunity for creative growth. When working with data structures, it is essential to choose the most appropriate type (such as an array, linked list, tree, or graph) for effectively storing and organizing data for a particular purpose. Another challenge I faced while working in Jupyter was testing, making it difficult to implement practices like unit testing.

Overall, I gained substantial experience in implementing robust development practices that are necessary for a production environment. I have made considerable progress in achieving my personal and professional objectives. This was my first experience working with MongoDB. During my course, I encountered difficulties grasping MongoDB's query language and index design. While working on the project, I faced challenges such as resolving connection issues between Jupyter Notebook and MongoDB, along with debugging intricate queries, which required a comprehensive understanding of both tools and a sharp attention to detail. Throughout this study, I learned the distinctions between relational databases (SQL) and NoSQL databases (NoSQL). With MongoDB’s flexible schema, capable of storing various data types within a single collection, it is well-suited for handling unstructured and semi-structured data. Utilizing a client library like PyMongo, I became adept at performing CRUD (Create, Read, Update, Delete) operations on MongoDB. This experience taught me how to utilize these tools effectively for data-driven projects and refined my understanding of the data analysis process.

Furthermore, I can showcase this project in my resume and portfolio, which will enhance my job applications and interviews. By working on this artifact, I have advanced my personal and professional aspirations by refining my skills, expanding my knowledge, and gaining valuable experience. Additionally, comprehending algorithms and data structures involves building a strong foundation in computer science that will contribute to becoming a more proficient programmer.

**References**

*Best way to teach data structures and algorithms? | Researchgate. (n.d.-b). https://www.researchgate.net/post/Best\_way\_to\_teach\_Data\_Structures\_and\_Algorithms*