









Research Article



Rumetrics: A Digital Solution for Precision Livestock Data Management and Genetic Selection in Developing Countries

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ABSTRACT

Introduction: Collecting and managing livestock data is essential for improving the efficiency of genetic selection and supporting data-driven decisions, ultimately enhancing productivity and profitability. Despite growing recognition of its importance, especially with the advent of precision agriculture, livestock data management remains a significant challenge due to the limited availability of user-friendly digital tools, particularly in developing countries. This study aimed to present Rumetrics, a desktop application designed to facilitate the entry, management, and exploration of livestock morphometric data for farmers and researchers.

Materials and methods: Rumetrics was developed using ElectronJS, AngularJS, and SQLite to provide a local, offline solution for livestock data management. The application enables users to input morphometric measurements, organize datasets, and perform descriptive statistical analyses. Automated features such as graphical visualization were incorporated to enhance usability and support informed decision-making without requiring an internet connection.

Results: Implementing Rumetrics allowed users to efficiently store, manage, and analyze livestock morphometric data. The application provided intuitive graphical analyses and comprehensive statistical summaries, making data exploration accessible to both researchers and livestock professionals. User feedback indicated increased efficiency in data handling and improved capacity for data-driven decisions compared to the manual methods.

Conclusion: Rumetrics as an offline application proved to be an effective tool for local livestock data management, offering accessible storage and real-time statistical analysis.

1. Introduction

Small-scale livestock production remains a crucial component of agricultural activities and socioeconomic development, particularly in developing countries. In these nations, such activities continue to provide a vital source of protein and income for millions of people¹⁻³.

As the demand for livestock products continues to rise due to population growth and urbanization, finding inexpensive tools to enhance livestock productivity has become a pressing concern⁴. In this context, the field of livestock morphometrics, a quantitative analysis method for phenotypes, continues to be one of the most powerful tools

for researchers and policymakers in the livestock industry, particularly in developing countries.

Studies in morphometrics have been extensively published across various academic databases, which including but not limited to Google Scholar, PubMed, Scopus, Springer, and Wiley. This reflects a strong interest in this field^{5,6}. However, managing and preserving livestock data presents significant challenges, especially in developing countries where free access to practical digital tools is limited⁷. This limitation slows down the efficient use of morphometric data for improving livestock productivity.

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Several developing countries face food shortages, water scarcity, and disease outbreaks, which are impacting livestock production. To address these challenges, innovative approaches have been employed to enhance the exploitation of genetic resources and protect animal health^{8,9}. In today's world, the importance of integrating technology into livestock management is increasingly recognized. These practices could minimize the effects of different challenges. Moreover, recent advancements in digital tools and data analysis platforms exhibited their potential to improve livestock research by enhancing data management, analysis, and dissemination^{9,10}.

This paper provides a comprehensive overview of Rumetrics, detailing its technical architecture, features, and potential impact on livestock research and production. The main objectives of the application are to simplify data entry, to store and manage data, and to explore data in real-time through the integration of statistical and graphical analysis.

2. Materials and Methods

2.1. Technology stack and development environment

Modern technologies were used in the development of Rumetrics to guarantee its efficiency. ElectronJS, which enables the development of cross-platform desktop applications with web technologies, is the basis of the application¹¹. Additionally, AngularJS was used to design the frontend¹². This toolset helps in the development of an interactive and dynamic environment for users. Furthermore, the backend is supported by Node.js and Express, which generally allow building simple and efficient web applications using JavaScript on the server.

SQLite is the most used SQL database engine; it is a lightweight relational database that promises quick and safe data storage and handles data management¹³. Additionally, SQL is used for database queries, which enhances the efficiency and organization of data retrieval. Visual Studio Code (VSCode), a versatile and powerful editor for coding and debugging, was used to build the development environment¹⁴. Moreover, system diagrams were created using PlantUML software, which helps to visualize the software architecture clearly^{15,16}.

2.2. System architecture

Rumetrics is based on a modular architecture. This approach is common in software engineering. It helps improve maintainability, scalability, and clarity. The architecture reveals three layers (Figure 1), which are the Presentation Layer, Business Logic Layer, and Data Layer. Each layer has a specific function. This Architecture makes the system efficient and well-organized.

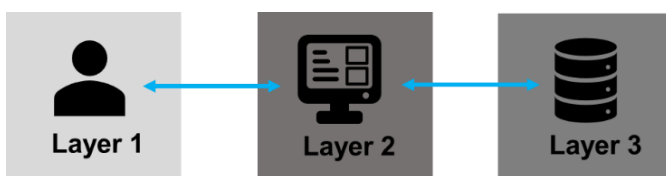


Figure 1. System architecture of Rumetrics: Layer 1: Presentation Layer, Layer 2: Business Logic Layer, Layer 3: Data Layer (Designed by authors)

2.2.1. Presentation layer: AngularJS for GUI development

The Presentation Layer is the frontend of Rumetrics. It provides the user interface (UI). This part was developed using AngularJS, a framework for building dynamic web applications. The functions of this layer consist of displaying the visual parts of the application and managing user interactions such as adding, editing, and analyzing data. Other functions are essential in this layer. They include using two-way data binding to update the interface in real-time, supporting modular components to improve reusability, and handling navigation and state management to ensure a smooth user experience. With AngularJS, Rumetrics becomes user-friendly, allowing researchers and breeders to interact with data easily.

2.2.2. Business logic layer: ElectronJS for core functionalities

The Business Logic Layer connects the frontend with the database. It was developed using the ElectronJS framework for desktop applications. This layer offers several functions, from which users could cite processing and validating data, ensuring proper communication between the UI and the database, and handling file management. It allows users to access data without an internet connection. Hence, Rumetrics can be presented as an application that combines the flexibility of web technology with the performance of desktop applications.

2.2.3. Data layer: SQLite for structured data storage

The Data Layer is responsible for storing and retrieving data. Rumetrics uses SQLite, a simple but powerful relational database. This layer has several purposes; It stores livestock data, statistical results, and user settings. It organizes data into structured tables for efficiency. It runs fast and optimized SQL queries. It also allows for importing and exporting data in different formats. SQLite is lightweight and fast. It integrates easily with ElectronJS. This makes it a good choice for local data storage in Rumetrics.

2.3. UML class diagram of rumetrics

A UML class diagram provided in Figure 2 illustrates the core functionalities of Rumetrics. It displays the relationships between the following components:

2.3.1. User class

The central entity is responsible for managing operations. It includes recordData, manageData, analyzeData, and configureSettings.

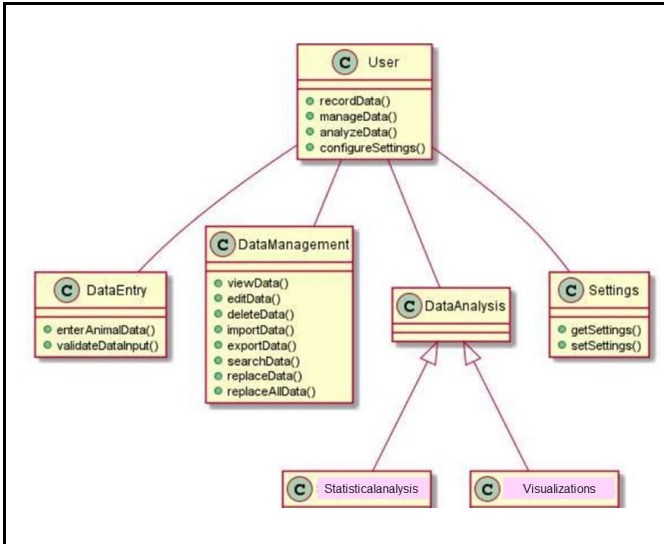


Figure 2. UML Class Diagram Illustrating Core Functionalities of Rumetrics. This diagram shows the relationships and operations within the Rumetrics application. It provides details regarding the interactions between the User class and the DataEntry, DataManagement, DataAnalysis (including StatisticalAnalysis and Visualizations), and Settings classes, which facilitate efficient livestock data management and analysis (Designed by authors).

2.3.2. Data entry class

It handles the input process with functions such as enterAnimalData and validateDataInput.

2.3.3. Data management class

It controls operations related to stored data, such as viewData, editData, deleteData, importData, exportData, and searchData.

2.3.4. Data analysis class

It is directly linked to Statistical Analysis and Visualizations, and it helps users to interpret data efficiently.

2.3.5. Settings class

It facilitates the getSettings and setSettings functions. These settings enable users to tailor the system to their specific needs.

2.4. Implementation and features

2.4.1. User interface and data management

Rumetrics is a desktop application for managing livestock data. It helps researchers and breeders to collect, store, and organize animal records. Additionally, users can enter various types of data, including animal identification, species, breed, sex, birth date, and region. The application also allows recording breeding information, including mother and sire identification, breeding system, kidding date, and litter size. It includes fields for body measurements, such as weight, head length, body length, and chest circumference (Figure 3). Features related to descriptive parameters (coat, color, head profile, ear posture) are available as well. The data is saved in a structured way, making it easy to retrieve and analyze. Besides, users can

also import data from an Excel file or a text file with information separated by commas (CSV) for exporting the data into a file type that stands for JavaScript Object Notation (JSON), an Excel file, or a text file format (TXT) for further processing.

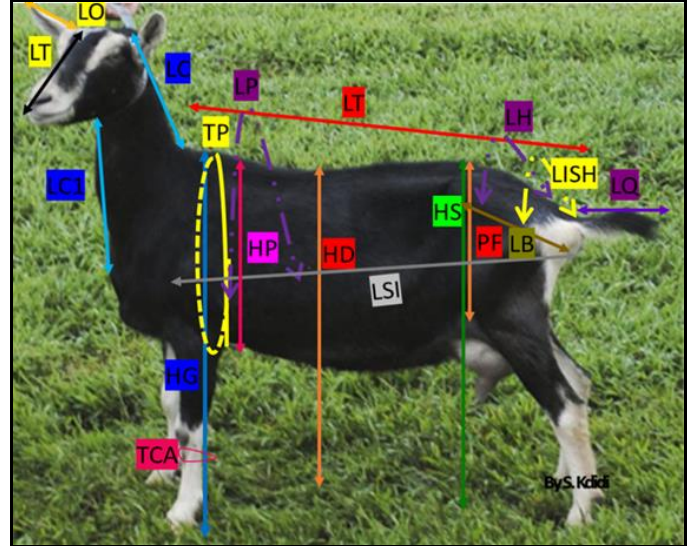


Figure 3. Main body measurements are available in the application. LT: Length of head, LO: Length of ears, LC: Upper Neck Length, LCI: Lower Neck Length, LT: Length of body, LB: Length of pelvis, LH: Width at hips, LISH: Ischial width, LSI: Scapulo-ischial length, TP: Chest circumference HP: Depth of chest, LP: Width of chest, HG: Height at withers, HD: Height at back, HS: Height at sacrum, Pf: Flank depth, LP: Coat length, TCA: Circumference of front cannon, Lq: Length of tail (Designed by authors)

2.4.2. Statistical and graphical analysis

Rumetrics provides tools for statistical analysis. Users can generate histograms and box plots to visualize the distribution of their data. A histogram displays the frequency of occurrence of a value in a dataset. Besides, a boxplot helps to detect variations and identify extreme values. These tools allow researchers to compare animal traits and study growth patterns. Visual analysis helps to understand genetic differences and environmental influences. Additionally, the application facilitates the interpretation of complex data and supports informed decision-making in livestock research.

Rumetrics also includes statistical analysis. For numerical input, it calculates the mean, median, standard deviation, variance, and coefficient of variation. These values help to summarize and compare data. Additionally, the application offers percentile analysis, skewness, and standard error. These calculations enable researchers to examine data in greater detail. For categorical input, it calculates the total count of observations, the number of unique categories, the most frequently occurring category, the count of the most frequently occurring category, the percentage of the most frequent category, the Shannon Diversity Index, and Simpson's Diversity Index (D). It also provides a table of value distribution.

Rumetrics provides tools for visualization. For numerical

input, the application allows the user to draw a Bar chart, line chart, histogram, box plot, and density plot.

Users can generate histograms and box plots to visualize data distribution. A histogram displays the frequency of occurrence of a value in a dataset. Besides, a boxplot helps to detect variations and identify extreme values and outliers. These tools allow researchers to compare animal traits and study growth patterns. Visual analysis helps to understand genetic differences and the influence of environmental factors. Additionally, the application facilitates the interpretation of complex data and supports informed decision-making in livestock research and herd management.

2.5. User interaction and functionalities

To explain the interaction and functionalities in this application, a use case diagram is provided in Figure 4. It would be helpful to understand how users interact with the system. On the left side, there is a user, which is a person in this case. The user interacts with the application and has a specific role in the system. On the right side, there are use cases or functions. A use case represents a function of the system and defines the main tasks that the system can perform. The lines between users and functions show relationships. A solid line means that the user interacts directly with the function. A dashed line means an optional or extended interaction.

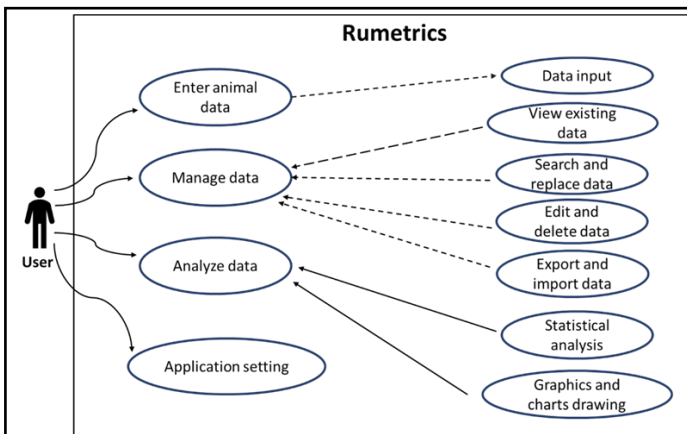


Figure 4. UML Class Diagram of Rumetrics. This diagram depicts the modular structure of the Rumetrics application. It illustrates the relationships and interactions between key components (User, DataEntry, DataManagement, DataAnalysis) and Settings classes. Hence, it could support livestock data management and analysis functionalities (Designed by authors).

3. Results and Discussion

In the present study, the performance of Rumetrics has been evaluated. It is a desktop application in development, focusing on storing, managing, and analyzing data related to livestock morphometrics. The present assessment focuses on

data management efficiency, statistical analysis capabilities, and visualization tools (Figure 5).

3.1. Management efficiency

Rumetrics simplifies data entry either directly from a paper or an Excel (XLSX) or comma-separated values (CSV). Users can input various animal details, which could include identification, breed, and morphometric measurements (Figure 5). The application also supports exporting to formats like XLSX file, a text file (TXT), a JavaScript Object Notation file (JSON), and a CSV file as well. These options facilitate data integration, sharing among researchers, and further use as input files for different software for advanced analysis.



Figure 5. Workflow of Rumetrics Application for Livestock Data Management. This figure illustrates the process of data collection, entry, and analysis using Rumetrics. It highlights the application’s development using several technologies, including ElectronJS, AngularJS, and SQLite, which enables data import/export in formats such as CSV, XLSX, JSON, TXT, PNG, and SVG. Besides, its Key functionalities include descriptive statistical analysis (mean, median, mode, etc.) and visualization through various plots. Thus, it could support livestock researchers and farmers in data-driven decision-making (Designed by authors) .

3.2. Statistical analysis capabilities

The application offers user statistical tools for getting a real-time idea of their data evolution. These tools enable the user to calculate the most common and interesting descriptive statistics such as mean, median, standard deviation, and variance. Moreover, Rumetrics computes diversity indices for categorical data. It includes the mode, Shannon's, and Simpson's indices.

3.3. Visualization tools

Researchers in morphometric studies utilize data visualization as an efficient tool that enables them to present their research results in a more comprehensive and visually appealing manner. It was interesting to include plotting tools in Rumetrics. This application provides various visualization options, including bar charts, line charts, histograms, box plots, and density plots (Figure 6). These tools facilitate real-time

identification of trends within the data, thereby improving the interpretation of data evolution.

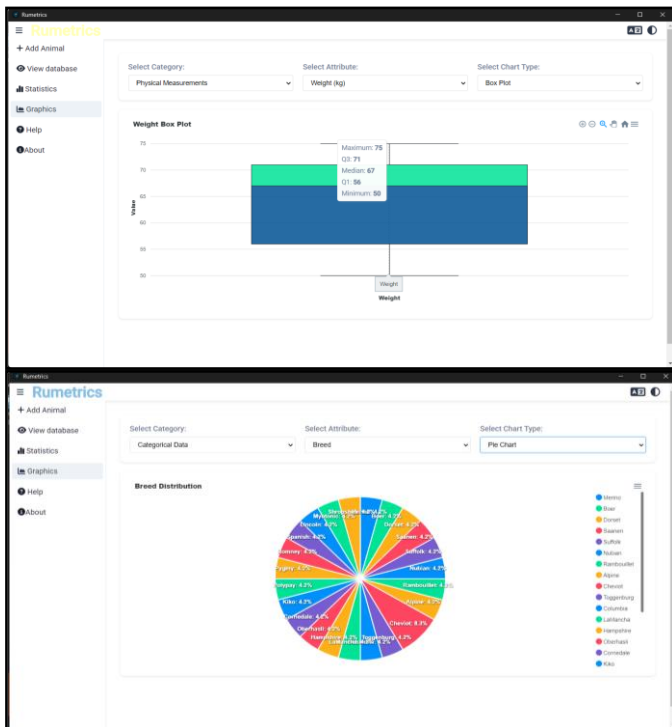


Figure 6. This is a screenshot of the Rumetrics User Interface, which demonstrates visualization tools. The upper panel shows a box plot for weight (kg) under the “Physical Measurements” category. It highlights statistical measures, including the minimum (50 kg), maximum (75 kg), and median (67 kg). The lower panel displays a pie chart of breed distribution under the “Categorical Data” category, which illustrates the proportion of various breeds in the saved dataset. These panels explained why this application could support livestock data analysis and contribute to decision-making (Design by authors).

3.4. Impact on livestock research

Rumetrics is expected to have a significant impact on livestock research and production.

3.4.1. Genetic improvement

Across studies, it is well established that morphometric traits play a crucial role in assessing livestock potential, particularly in terms of meat production, milk production, and reproduction. These traits, such as length of pelvis, width at hips, ischial width, scapulo-ischial length, chest circumference, depth of chest, width of chest, height at withers, height at back, height at sacrum, flank depth, provide valuable perceptions into an animal's growth potential, body composition, and reproductive capacity. In this context, indices like the anamorphosis index (IA) can indicate the aptitude of an animal for meat production by connecting the height at the withers to the thoracic perimeter.

A higher IA suggests a higher meat produced producing¹⁷. Similarly, Figueiredo-Filho et al.¹⁸ reported that the pelvic index (IP) and dactyl-thoracic index (IDT) are used to evaluate the ability of an animal to produce meat and the refinement of its skeleton.

In dairy livestock, morphometric traits can predict their

potential for milk production¹⁹⁻²¹. Reproductive performance in livestock could be affected by morphometric characteristics. For instance, scapulo-ischial length and ischial width are considered indicators of pelvic size and reproductive efficiency²². A wider pelvis facilitates easier calving and better reproductive outcomes. Furthermore, researchers can use Rumetrics to efficiently explore and analyze morphometric data, identifying superior individuals for selection and thereby accelerating genetic gain.

3.4.2. Sustainable livestock production and climate change

Using Rumetrics, Farmer might monitor his herd efficiently. In fact, some attributes available in this application, such as livestock system and diet, can help him evaluate the effect of his feeding strategies on his animals and his profitability. In this context, Rumetrics can be used to monitor animal growth and body condition in response to different feeding strategies, enabling farmers to optimize feed utilization and minimize environmental impact. Furthermore, Rumetrics could assist farmers in selecting the animals that show a better adaptation to changing climatic conditions.

3.4.3. Conservation of indigenous breeds

According to Hoffmann²³, there is a need, especially in developing countries, to support the efforts of livestock conservation programs. Rumetrics is designed to contribute as a tool in these interesting programs. In fact, it offers a collection, management, and analysis of morphometric data. Thus, it might be used to carry out even in the characterization of breed diversity, identification of unique traits, and development of conservation plans.

3.5. Comparison with existing tools

While existing tools for morphometric data analysis are available²⁴⁻²⁷, rumetrics offers the advantage of offline functionality, making it accessible in field settings without the necessity of an internet connection. Its integration of data management, statistical analysis, and visualization within a single platform reduces the need for multiple software tools, thereby increasing its efficiency. Furthermore, Rumetrics is designed explicitly for livestock morphometrics, offering personalized features and a user-friendly interface for livestock researchers and breeders.

While Rumetrics offers several advantages, it has some limitations. The application currently lacks cloud storage capabilities and automated data entry from digital measuring devices. However, these limitations should not be considered grave concerns, as the software is designed to be easily used, even by smallholders with limited educational backgrounds, particularly in developing countries where internet connections may be unavailable.

4. Conclusion

In livestock research and sustainable production, there is an

increasing demand for a user-friendly tool to input, manage, and analyze data, especially for morphometric characterization. Rumetrics is a desktop application that enables farmers, technicians, and researchers to create their own databases. It provides real-time statistical analysis, supporting better decision-making in animal management, conservation, and genetic improvement. This has become possible because real-time statistical analysis tools are available within this application. Although Rumetrics has some limitations, such as Cloud storage and automated data entry from digital measuring devices, it remains efficient in supporting small breeders and scientists, especially in developing countries.

Declarations

Competing interests

The authors declare that they have no competing interests.

Ethical considerations

Plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been checked by all the authors.

Authors' contributions

Samia Kdidi handled conceptualization, formal analysis, investigation, supervision, software validation, writing the original draft, review, and editing. Oussama Halmous conducted investigation and methodology. Hathami Hajji and Mohamed Dbara reviewed and edited the manuscript. Mohamed Hammadi, Touhami Khorchani, Sghaier Najari, and Mohamed Habib Yahyaoui handled acquisition, review, and editing manuscript. All authors read and confirmed the final edition of the manuscript.

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Availability of data and materials

The application could be downloaded at <https://github.com/SKdidi82/Rumetrics>.

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