Machine Learning-Enabled Menstrual Cycle Prediction and Analytics in a Secure Web-Based Platform

Yogesh Pawar, Apurva Gangrade, Archita Tiwari, *Shivprasad Chinchole*, Vaibhav Chandwalk-er

Department of CSE– Internet of Things and Cybersecurity including Blockchain Technology, Vishwakarma Institute of Technology, Pune, Maharashtra, India

yogesh.pawar@vit.edu

Abstract: Menstrual health tracking is a significant aspect of digital health, and women use various apps for menstrual cycle prediction. However, these apps do not provide accurate prediction and analytics [2]. To solve this problem, a web-based platform named CycleCare is developed. This platform uses various data analytics and prediction techniques. According to research, physiological variables and self-tracked data are useful in improving menstrual health analysis [1, 3, 9]. In the proposed system, generative and time-series models are used for predicting menstrual cycle lengths and phase changes. These models can handle irregular menstrual cycles and missing data [7, 10, 11]. Furthermore, the proposed system is developed considering user engagement, user experience, and data privacy, making it a health application [5, 6, 8].

Keywords: Menstrual Cycle Tracking; Predictive Modeling; Machine Learning; Mobile Health (mHealth); Self-Tracked Data; Web-Based Health System

1. Introduction

1.1. Background

Menstrual health plays a vital role in ensuring proper physiological health. In addition to that, various patterns and predictions can be made in relation to the menstrual cycle by tracking it. Unusual occurrences can also be monitored in relation to the menstrual cycle. However, by using conventional and traditional methods of tracking the menstrual cycle, only basic accuracy and minimal analysis of the cycle can be made. In recent times, various digital health tools and applications, especially related to tracking the menstrual cycle, have become highly popular and widely used due to their accessibility and versatility [2]. However, various applications and tools lack ad-vanced predictive analysis and use minimal tracking data for generating maximum health-related insights and analysis [3, 9]. Current research findings indicate that large-scale, data-driven methods have the potential to identify physiological trends

M. Kaushik et al. (eds.), *Proceedings of the International Conference on Responsible, Risk-aware, and Regulated AI (RRRAI 2026)*, Advances in Intelligent Systems Research 210,
https://doi.org/10.2991/978-94-6239-723-1_43

and inter-individual variability that cannot be identified using traditional methods [9]. In addition, research studies that have included physiological parameters, such as basal body temperature, have shown that sensor-derived data could improve the accu-racy of phase prediction [5]. Recent reviews have highlighted the application of ma-chine learning and omic based methods for advancing the understanding and model-ing of menstrual health [4].

1.2. Problem Statement

Even though the number of menstrual cycle-tracking applications is increasing over time, several issues still remain: Most of the existing tools do not have reliable, user-friendly interfaces for the consideration of individual variability and comprehensive cycle prediction models, which results in less accurate or generalized forecasts. Additionally, it should be noted that many apps do not specifically state how the prediction of the cycle is made, which might affect users' trust in the app. Apart from that, there are issues of privacy, security, and accessibility since users are not sure how their data is stored or shared. The simple calendar-based apps take into consideration only regular cycles and the existence of self-tracked entries or their lack, thus further limiting the value of forecasts made for people with different cycle patterns

1.3. Objectives of the Study

The main aims of this research are to:

1. Getting accurate cyclic records of menses using self, reported, as well as model, improved data
2. Menstrual and ovulation cycle phase predictions in the next cycle through effective and data-oriented modeling techniques, which are able to model irregularities and missing information.
3. Supporting clients with provision of symptom tracking and self care information to aid comprehension of physical and emotional changes occurring in the body. This is consistent with recent research into advanced analytics and user, focused features that discovered applications containing such elements would increase the value of applications for tracking one's menses [3, 9].

1.4. Contributions of the Work

A web-based and responsive interface for easy access and usage across devices; stronger authentication methods for data privacy and security; and the use of statistical and machine learning algorithms (e.g., generative and time series models) for accurate cycle prediction and data visualization. The contributions of this proposed solution aim to overcome the limitations of current menstrual cycle tracking ap-plications through the use of advancements in prediction modeling [1, 7, 10] and self-tracked data analysis [9].

2. Literature Review

2.1. Existing Menstrual Tracking Applications

technology-based applications for menstrual tracking, where users can track their menstrual cycle, symptoms, moods, and other health-related issues. Reviews have shown that these applications are more convenient and helpful for self monitoring [2]. Many such applications allow users to track their menstrual cycles and symptoms, enabling them to predict future phases. Also, large-scale mobile health data analysis shows that self-tracking is helpful for generating useful datasets for understanding physiological and symptom patterns [9].

2.2. Limitations of Current Systems

Existing menstrual tracking systems have gained popularity [2], but they are also facing various challenges. First of all, the systems lack medical accuracy. Most of the applications are based on simple algorithms without the use of advanced statistical models. It has been found that the use of advanced models like generative models and time series is more accurate [7, 11]. Another challenge is the privacy of the data. Most of the applications have failed to ensure the privacy of the data. Users are not aware of the data being collected from them. It has been found that the data collected is sen-sitive, and the usage of the data is not clearly communicated [6]. Most of the ap-plications have failed to ensure the inclusivity of the system. Irregular cycles, non-binary individuals, and cultural differences are not being considered. A general ap-proach is being applied without considering the differences [3, 8].

2.3. Research Gap

Earlier research has demonstrated the value of self, the tracking mechanisms available for menstruation cycles, as well as the value of the data individualized collection holds for harvesting different insights. However, till date, there exists no solution available that can weave together the necessary components of se cure and accessible AI analytics with the principles of responsible design on a universal level. Additionally, normally, the methods of the models in these applications are not clearly delineated in a way that makes them easily understandable and trustworthy for the end-users and the profes-sionals [1, 4]. Moreover, the addition of the privacy-preserving factors in a way that ensures a balance between predictions and the righteous use of data in menstruation cycle Health Apps has still been very less.

3. Proposed System (CycleCare)

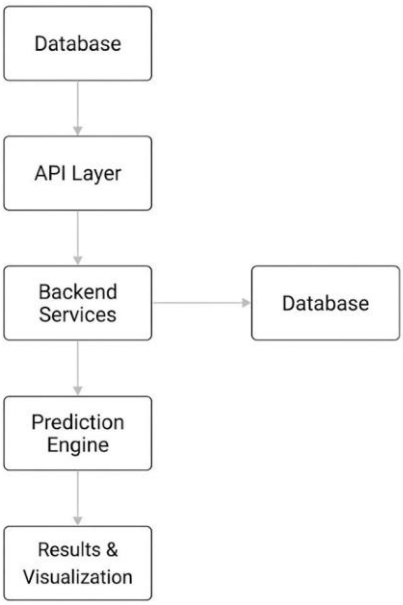
3.1. System Overview

beyond simple menstrual cycle tracking and provides predictions for menstrual health. Users can track their daily physiological events, symptoms, and lifestyle activ ities. A set of algorithms is applied to analyze the data and provide predictions for the user's future menstrual cycle phases, such as menstruation and ovulation. Presently, menstrual health tracking applications are using a set of heuristic-based methods. These methods are found to be less effective for women experiencing irregular peri-ods and varying degrees of symptoms. A study points out the importance of using self-tracking data and prediction models for improving accuracy and physiological insights.[9].

3.2. System Architecture

The architectural style used for implementing CycleCares is a clean and module-based style. The style is scalable and provides a clean demarcation of user interfaces and backend systems and analytics engines. The following are the major modules implemented as part of the system:

- User Interface (UI): This module includes various types of screens for enter-ing cycles, for entering symptoms, and for entering dashboard screens.
- Application Server: This handles the API request, implements the process logic, and steers the data. Prediction Engine: It holds the predictive models used in the forecast of cycles based upon user inputs as well as the historical record.
- Database Layer: Stores the user profiles, cycle information, symptoms, and the model.



4. Technology Stack

It is built upon an innovative technology stack for web application development, which ensures the application is secure, scalable, and faster:

1. Frontend Layer

- React; is a library of JavaScript used for developing GUI and creating responsive UI
- Tailwind CSS: A utility-first CSS framework that allows for rapid user interface and styling implementation..

2. Backend Layer

- Node.js: JavaScript runtime for the development of network programs.
- Express.js; a lightweight web framework for the development of RESTful APIs is referred to as Express.js.

3. Database

- MongoDB: is a NoSQL database, which has a flexible, document-based database structure to store multiple types of data from users.

4. Authentication & Security

- JSON Web Tokens (JWTs) are used for stateless, safe user authentication.
- BCrypt: This hashing algorithm is used to store and verify passwords scurely..

5. System Design and Methodology

5.1. Design Approach

In relation to the scalability, maintainability, and development, CycleCare's system design is based on a modular architecture which breaks the major system problems into distinct modules. This is because the architectural separation between the back-end and frontend of the system acts as the divider between the backend development of services of data management, business logic, and analytics, and the development of the frontend components of the system, for example, the dashboards and the input forms. This ensures that the interface of a user with the application remains respon-sive despite computational growth in the backend of the application, by separating different layers of a system. Testing, debugging, and deployment of applications in different environments become easier through modularity. For health technology ap-plications, which normally require strong backend analytics and higher-level user interaction, similar tenets are cited in various works.[6, 2].

5.2. Data Flow

The process of CycleCare occurs through the step-by-step process of the data flow, which ensures the user input is processed entirely for meaningful outputs. This process is depicted as follows:

1. User Input: Inputting the details regarding the dates of menstruation, symptoms, and lifestyle factors occurs through the front-end user interface for users.

2. Backend API: This process involves sending the input details through API calls to the back end server using REST API.

3. Database Storage: This process involves receiving and verifying the input details at the back end server and then storing them in the database (MongoDB).

4. Prediction & Analytics: This process involves making predictions based on the input details through the combination of historical data and user trends.

5. Dashboard Rendering: This process involves sending the results and prediction details back through the back end server to the front end user interface for users.

At each step of the processing pipeline, the system aims to maintain integrity of the data and offer real-time feedback to the user, while at the same time protecting the privacy and security of the user.

5.3. Prediction Mechanism

One of the best or even the best features that CycleCare provides is its accurate prediction of the time of the next menstruation and ovulation. In fact, it can be said that the forecasting system of CycleCare is more accurate than any other forecasting system that relies on data averages and data modeling techniques.

The prediction mechanism of CycleCare consists of the following:

- Historical Pattern Analysis: This is where the system analyzes the length of the cycle of the user in the past, which was previously recorded, in order to develop a pattern of the user's behavior according to their past activities.
- Time-Series and Generative Models: After this, according to the passing of time, the cycle analysis methods are incorporated in a manner that is similar to a generative predictive model, which is capable of addressing missing data and varying times between cycles [7, 11].
- Statistical Smoothing & Confidence Estimates: After this, the output of the models is further processed in a manner that uses statistical smoothing in an attempt to prevent peak predictions for unusual conditions.
- Continuous Updating: Every time the user updates the system with their latest information, the system is constantly updating its predictive model with

minimal error, and in this regard, it is somewhat similar to the adaptation aspect of the latest research in the prediction of menstrual cycles [9].

This is where the use of the combination of all these aspects allows the system to make accurate predictions for the next period and ovulation, not only making it easier for one to plan ahead but making their tracking worthwhile.

6. Implementation

6.1. User Authentication Module

accessing the CycleCare system. Users can register their accounts by entering their email and password. The passwords are encrypted and stored in a database. When users want to access their accounts, their passwords are validated, and a JWT token is offered. Access control for users' data, such as cycle and symptom data, is offered by token-based authentication. This ensures that users are authenticated before accessing their data. This module offers security and a good experience for users.

6.2. Cycle Tracking Module

The Cycle Tracking Module enables users to enter and view their menstrual cycle details:

- Calendar Based Logging: Using an interactive calendar system, the user is able to enter the first and last dates of their periods. An interface as simple as this will help ensure that the logging is done on a regular basis and is also error-free as it does not involve manual logging.
- Past Cycle Visualization: In the calendar and timeline views, the past dates for the cycle, which were recorded earlier, are displayed; therefore, it be comes easy for users to track their past cycles and patterns. Users are able to identify anomalies and patterns in time.

This solution considers a positive user experience and return traffic of users to their data related to their personal health.

6.3. Symptom Tracking Module

common menstrual and associated symptoms:

- Symptom categories: The user can specify different symptoms such as cramps, mood swings, sleep problems, belly swelling, tiredness, and many others. ● Daily Logging: It is possible to log symptoms daily so the system figures out the relation of symptoms with different stages of the cycle.
- Customizable Inputs: Users are allowed to insert symptom tags for a more personalized logging experience.

As soon as symptom data is merged with cycle dates and prediction results, richer interpretations will be enabled.

6.4. Dashboard and Visualization

The user is also able to access summarized data and analytics about their health from the dashboard. Chart.js library is used to create line charts, bar graphs, and heat maps to facilitate data visualization. The user is also able to analyze the duration of the menstrual cycle. Prediction of the next phases is also shown. These phases include menstruation and ovulation. The user is able to comprehend complex data.

6.5. Self-Care and Community Module

Apart from the tracking and forecasting, the advocacy for constant support includes the integration of various modules via Cycle Care for education and community participation:

- Educational Videos: With the assistance of the platform, the reader is directed to various educational videos filled with useful information and tips regarding women's health, self, care, workouts, and stress.
- Q&A Forum: Members of the community are aided and assisted through the discussion forums or simply through posting a query. The utilization of moderation ensures helpful and correct interactions.

These aspects increase the capacity for self-care among the users while at the same time establishing a physically and emotionally safe space for sharing in matters concerning menstrual health.

7. Performance Analysis

Performance metrics mainly revolved around system response and the reliability of the predictions made:

7.1. Load Time

Major interface elements, e.g., cycle dashboard and prediction panels, were eval uated under network conditions that replicate the reality. Each of the tested components consistently loaded within the threshold of acceptable levels of in teractivity during the tests.

7.2. Prediction Reliability

CycleCares forecasting module is a tool that predicts menstrual cycles and ovulations using historical self, tracked data. When tested against a dataset compris ing real user, logged cycles, the model’s predictions were accurate to the actual timing of the events with a probability around 0.91, which basically means that in about 91 cases out of 100 that were evaluated, the actual start of the cycle was within the predicted interval.

Expressing this level of performance in terms of probability is consistent with probabilistic modelling methods and reflects the level of confidence in the prediction outcomes rather than simply the accuracy of the results.

7.3. Feature-wise Results

Below is a summary of system features and their evaluation outcomes: This feature-wise evaluation demonstrates that the system not only performs core functionalities effectively, but also meaningful insights and solid user experience. provides

Table 1: Feature-wise Performance Evaluation of CycleCare (Source: Author compilation)

Feature	Evaluation Outcome	Remarks
User Authentication Module	Functionally verified	Secure access with JWT an bcrypt; no unauthorized access
Cycle Tracking Module	Reliable	Calendar input intuitive; consistent data capture
Symptom Track- ing Module	Highly usable	Supported logging of mul- tiple symptom types
Dashboard & Visualization	Fast and informant	Chart.js displays clear cyc and prediction visuals
Predictive Engine	Forecasts with ~0.91 probability	Reliable interval coverage based on test cycle sequence
Educational & Community Tools	Positive engagement	Users responded well to curated content and Q&A forum

8. Discussion

8.1. Strengths of CycleCare

User Friendly: CycleCare is user-friendly, and this makes it possible for individuals of varying levels of proficiency to use it in the future for their cycle tracking, symptom monitoring, and understanding their predictions. A user-friendly interface is essential for a program to be useful in the future.
Secure: CycleCare is a privacy-focused app, and it has security mechanisms in place, such as JWT authentication and bcrypt password encryption.
Accessible: The application is web-based and therefore can be used on various gadgets, making it easily accessible for of different backgrounds.

8.2. Limitations

No Wearable Integration: Currently, CycleCare uses only self-reported data; it does not use wearable device data like temperature or heart rate to increase accuracy in predictions [5].
No Medical Grade Diagnosis: The system is intended to promote health awareness and prediction. Although machine learning can be used to predict certain things, users should consult a doctor in case of serious health concerns [7], [9].
Prediction Approximation: Even though the system can predict with a high accuracy level of 0.91 probability, it can be a result of inaccurate input data. This can happen because of difficulties in self-tracking health data [7], [11].

8.3. Summary

CycleCare shows plenty of potential to be a safe, convenient, and easy to use web-based solution for tracking and predicting menstrual health, thus filling the major gaps of the existing tools [2, 6].

9. Conclusion

CycleCare is a web-based application for tracking and predicting menstrual health using a user-friendly interface and advanced predictive modeling techniques. The application is found to have high predictive capabilities, as it is able to achieve a probability accuracy of 0.91 in predicting cycle start dates. The results of the application show that it is stable, interactive, and user-friendly. Using machine learning-based analytics and authentication, CycleCare is designed in a way that it overcomes the limitations of existing calendar-based applications for tracking and predicting menstrual health. Thus, it is considered a more accurate and user- friendly application. Various features of the application can be utilized for engaging users in their health and menstrual health. It is identified that the CycleCare applica- tion is a reliable one or improving and tracking menstrual health.

References

1. Yu, J.L. et al., Tracking of menstrual cycles and prediction of the fertile window via physiological measurements machine-learning algorithms.
2. Ko, S. et al., Menstrual Tracking Mobile App Review by Consumers and Health Care Providers.
3. Symul, L. et al., Assessment of menstrual health status and evolution through mobile apps for fertility awareness.
4. Ganguly, M. et al., A review on menstrual health in adolescent girls emphasizing multi-omics and machine learning strategies.
5. Maijala, A. et al., Nocturnal finger skin temperature in menstrual cycle tracking.
6. Schantz, J.S. et al., Menstrual Cycle Tracking Applications and the Epidemiologic Research. Potential for Epidemiologic Research.
7. Li, K. et al., Generative, predictive model for menstrual cycle lengths accounting for self-tracking artifacts.
8. Gompers, P. A., Metrick, A. Institutional investors and equity prices. Q. J. Econ.,

9. Li, K., Urteaga, I., Wiggins, C.H. et al., Characterizing physiological and symptomatic variation in menstrual self-tracked mobile health data. cycles using s elf-tracked mobile health data.
10. Duttweiler, L. et al., SkipTrack: Bayesian Hierarchical Model for Self-tracked Menstrual Cycle Length and Regularity.