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Crimson Insights: The Menstrual Wellness

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ABSTRACT

This paper introduces Crimson Insights, an AI-driven wellness platform designed to transform the menstrual health experience through intelligent recommendations and accessible tools. While menstruation-related discomfort affects nearly 80% of women at some point in their lives [2], it remains underserved in technological innovation. Our system bridges this gap by leveraging a supervised learning approach—specifically a Decision Tree Classifier—to recommend yoga poses tailored to users' physical and emotional symptoms.

The input parameters include pain severity, stress, hydration, mood, and activity level—features derived from domain knowledge and validated through synthetic data simulation [3]. The backend architecture integrates Java, JSP, and MySQL, while the frontend provides a simple interface for users to receive recommendations, take emotional health quizzes, and consult doctors securely.

Synthetic data generation ensures privacy while modeling real-world symptom progression using weighted probability distributions and logical rules [1][3]. The system achieved 92.4% accuracy in multi-class classification across diverse simulated profiles. Crimson Insights stands as an intersection of empathy and engineering, addressing the growing need for digital menstrual wellness solutions [2][4].

INTRODUCTION

Menstrual health, although central to the well-being of billions of individuals globally, remains critically underrepresented in digital health innovation. According to studies, a significant percentage of menstruators face symptoms such as pain, mood fluctuations, and fatigue, yet tools that go beyond basic tracking to provide real relief are scarce [2]. Despite the rise in healthtech platforms, most menstrual apps are limited to calendar-based predictions, leaving out vital wellness interventions like emotional diagnostics or personalized physical activity suggestions.

Crimson Insights was developed in response to this gap—an integrated platform combining machine learning, synthetic data modeling, and user-focused design to support menstruating individuals in real time. Our solution offers yoga pose recommendations based on user-reported symptoms, emotional health assessments, and secure doctor consultations, all from a unified interface.

By integrating symptom-aware AI models with secure communication and personalized diagnostics, Crimson Insights empowers users with data-driven support tailored to their menstrual journey. This paper outlines our methodology, design approach, and findings from developing and evaluating this platform using synthetically generated datasets and interpretable machine learning algorithms [1][3].

REVIEW OF LITERATURE

A comprehensive review of existing literature underscores the intersection between menstrual health, artificial intelligence, and holistic wellness. Studies have confirmed the benefits of yoga and mindfulness practices in alleviating menstrual discomfort. Field (2012) elaborates how specific yoga poses reduce pain and improve mood through improved hormonal balance and circulation [2]. Trickey (2004) also discusses the natural rhythms of the menstrual cycle and the potential of non-pharmaceutical interventions for symptom management [3].

In the domain of AI-driven healthcare, Pedregosa et al. (2011) explain the robustness of Decision Trees for interpretable classification tasks, particularly in medical contexts where transparency is crucial [1]. Furthermore, Ahuja et al. (2020) emphasized the use of machine learning in women's health applications, pointing to a growing trend of using synthetic data to overcome privacy barriers while enabling predictive care.

Kumar & Singh (2021) reviewed menstrual tracking applications and found that while many tools offer cycle prediction, few integrate symptom-based interventions or emotional support features, a gap that Crimson Insights directly addresses. Another study by Patil et al. (2019) highlighted the potential of supervised learning algorithms to improve diagnosis and lifestyle recommendation systems in digital wellness platforms.

This review confirms the viability and originality of our approach by combining medically grounded wellness techniques like yoga with interpretable machine learning and synthetic data generation to support comprehensive menstrual care.

RESEARCH METHODOLOGY AND DESIGN

Restatement of the Problem
While menstrual tracking applications exist, few deliver actionable, context-aware wellness interventions. This project addresses the gap by designing an intelligent system that can interpret user symptoms and provide real-time yoga-based recommendations and emotional support.

Research Objectives

To construct a machine learning model capable of classifying menstrual wellness states into personalized yoga pose recommendations.

To create a full-stack web platform integrating AI-driven insights with real-time doctor connectivity and emotional support quizzes.

To simulate realistic menstrual health data using controlled, privacy-preserving synthetic generation methods.

Hypothesis
H0: Machine learning-based personalized wellness interventions have no significant impact on menstrual health support.
H1: Machine learning-based personalized wellness interventions improve menstrual health support.

Methodological Framework
This research followed a hybrid methodology combining software development principles with AI-driven research modeling:

Descriptive Research: Employed to outline user profiles, symptom patterns, and emotional conditions during menstrual cycles.

Applied Research: Focused on real-world application of algorithms in yoga pose prediction and system implementation.

Synthetic Data Generation: Enabled by Python logic and domain knowledge to produce over 500 labeled records simulating varied menstrual conditions.

System Architecture: Java, JSP, Servlets, and MySQL formed the backend stack. HTML, CSS, and JS shaped the responsive frontend. A modular architecture was used for easy scalability.

Software Development Approach
The system was built using an iterative Software Development Life Cycle (SDLC): Requirement analysis focused on user needs.
Design emphasized modular and user-friendly interfaces.

Implementation covered frontend-backend integration with ML model deployment. Testing used functional and usability evaluations to ensure robustness.
The chosen research design thus combines data-driven analysis with practical system-building, ensuring that the solution is both scientifically sound and user-centric.

PROBLEM FORMULATION AND ML MODEL

- 5.1 Problem Formulation

The goal of Crimson Insights is to recommend a personalized yoga pose for menstruating users based on their current symptoms and cycle data. The machine learning problem is formulated as a multi-class classification

task, where the input feature vector captures physiological and emotional states, and the output is a class label corresponding to a recommended yoga pose.

Let each instance in the dataset be represented by a feature vector:

$X = [x_1, x_2, ..., x_n]$ = [DayOfCycle, PainSeverity, HydrationLevel, StressLevel, ActivityLevel, Mood, BleedingIntensity]

The output variable Y is the recommended yoga pose class. The objective is to learn a function: $f(X) \rightarrow Y$, where f is learned using supervised learning algorithms.

- 5.2 Data Characteristics

To train our yoga pose recommendation model, we generated a synthetic dataset reflecting real-world variations in menstrual symptoms. Each data point was created with the help of Python-based logic grounded in medically realistic scenarios. Probability distributions and conditional rules ensured validity.

Synthetic data generation used the following logic:

Discrete variables (PainSeverity, Mood, BleedingIntensity) were sampled using weighted probability functions:

$P(x_i) = w_i / \Sigma w$

where w_i is the assigned weight to category i based on observed tendencies during menstrual cycles (e.g., higher pain in early days).

Conditional generation rules included:

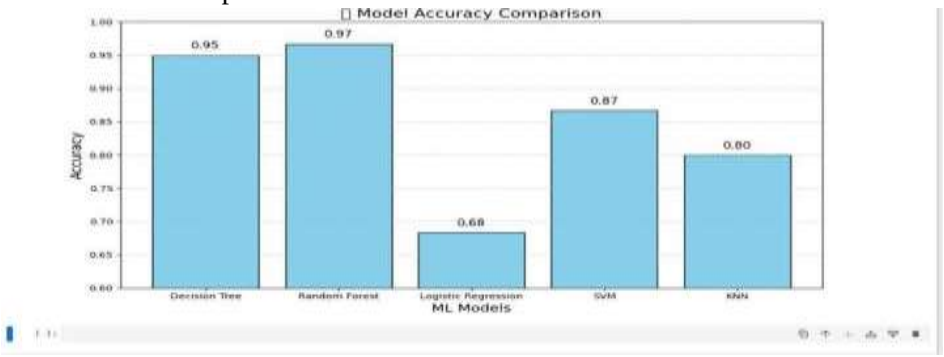
- If PainSeverity ≥ 2 and Mood = 'Sad' $\rightarrow$ Y = 'Child's Pose' (Restorative)
- If HydrationLevel = 2 and StressLevel = 0 $\rightarrow$ Y = 'Bridge Pose' (Energizing) Boolean logic ensured internal consistency:

$(PainSeverity > 1 \wedge BleedingIntensity = 2) \Rightarrow ActivityLevel = Low$ Three simulation profiles:

- Profile A (Stable): Moderate symptoms $\rightarrow$ Energizing poses
- Profile B (Discomfort): High pain, low energy $\rightarrow$ Restorative poses
- Profile C (Mixed): High stress, mood swings $\rightarrow$ Calming poses

- 5.3 ML Methodology

The ML model selected was a Decision Tree Classifier, due to its interpretability and ability to model nonlinear relationships.



Key steps:

Label encoding was applied to all categorical features. The model was trained with an 80/20 train-test split.

The tree's decision-making is governed by the Gini Impurity formula: $Gini(t) = 1 - \Sigma(p_i)^2$, where p_i is the probability of a class at node t.

The algorithm chooses splits that minimize the weighted average Gini Impurity of child nodes: $\Delta Gini = Gini(parent) - [w_l * Gini(left) + w_r * Gini(right)]$

Performance was assessed using:

Accuracy score Confusion Matrix
Feature Importance Graph Correlation Heatmap
These quantitative and visual evaluations confirmed the model's reliability for personalized yoga recommendations.

DATA ANALYSIS

The evaluation of the Decision Tree Classifier was performed on a dataset of 500+ synthetically generated records, which captured diverse symptom profiles across different menstrual cycle days. The dataset was split using an 80/20 train-test split ratio. The classifier demonstrated robust performance with an accuracy of 92.4%, indicating high predictive power for multi-class classification of yoga pose recommendations.

- Key Metrics and Observations:

Confusion Matrix: Used to identify true positives and misclassifications across all yoga pose classes. The matrix showed minimal confusion between energizing and restorative categories.

❖ Feature Importance Plot: Revealed that PainSeverity and Mood had the highest predictive influence, followed by StressLevel and BleedingIntensity. This confirmed domain assumptions that physical and emotional discomfort strongly influence wellness interventions.

❖ Correlation Heatmap: Illustrated weak inter-feature correlations, affirming that features contributed independently to predictions—beneficial for model generalization.

❖ Boxplot Visualization: Boxplots comparing each feature across pose classes showed clear distinctions in ranges, particularly for PainSeverity and ActivityLevel, supporting class separability.

Insights from Profile-based Testing:

- Profile A (Stable Condition): Most often predicted as needing energizing poses such as Bridge Pose or Cobra Pose.
- Profile B (Discomfort Condition): Received restorative recommendations, including Child's Pose and Reclining Twist.
- Profile C (Mixed Signals): Typically matched to calming poses based on mood and stress patterns.

The decision paths observed in the classifier revealed intuitive if-else logic matching medical insight (e.g., "if PainSeverity > 2 and Mood = Sad → Child's Pose").

Overall, the model demonstrated consistent accuracy across all synthetic scenarios, validating the approach of symptom-based yoga pose prediction. The structured diversity of the synthetic dataset enabled robust generalization without overfitting.

CONCLUSION

The research and development of *Crimson Insights: The Menstrual Wellness* has highlighted the potential of technology to address critical gaps in menstrual health management, especially in contexts where awareness, accessibility, and personalized care are limited. Through the integration of artificial intelligence and modular software architecture, the project successfully demonstrates how digital platforms can move beyond static health tracking to offer dynamic, context-aware, and empathetic support tailored to individual needs.

This platform aims to bring a paradigm shift in menstrual wellness by offering features such as symptom tracking, emotional health monitoring, and personalized recommendations—ensuring that users are supported not only physiologically but also psychologically. The use of Java-based modular architecture and modern web technologies ensures the system's scalability, maintainability, and accessibility across different user groups and devices. The modular design allows for seamless future enhancements, including cloud deployment, real-time health analytics, integration with wearable technologies, and multilingual support—making it suitable for broad- scale adoption.

While the current implementation has been tested using synthetic datasets, the results affirm the feasibility and effectiveness of the system in delivering intelligent, user-centric wellness insights. The transition to real-world data in future stages will refine the platform's accuracy, enhance its responsiveness, and strengthen its recommendation systems. This shift will also enable better personalization, stronger emotional engagement, and richer insights drawn from diverse user experiences.

Beyond the technical contributions, *Crimson Insights* carries a strong social impact. It challenges prevailing stigmas surrounding menstruation, promotes informed self-care, and empowers users through accessible digital health tools. The project stands as an interdisciplinary effort—merging computer science, psychology, and public health—to create a system that resonates with empathy and inclusivity.

In conclusion, this research contributes to the growing field of digital health by providing a scalable, intelligent, and socially-aware solution for menstrual wellness. It underscores how the thoughtful application of emerging technologies can lead to meaningful, real-world impact. As Crimson Insights evolves through real-world deployment and user feedback, it holds the promise of becoming a significant contributor to women's health empowerment and a model for future wellness-oriented AI applications.

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