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ПОВЫШЕНИЕ БЕЗОПАСНОСТИ И ПЕРСОНАЛИЗАЦИИ ТЕЛЕМЕДИЦИНЫ С ПОМОЩЬЮ БИОМЕТРИИ ЭКГ: КОМПЛЕКСНЫЙ АНАЛИЗ

Аннотация*: в статье рассматривается интеграция биометрических данных электрокардиограммы (ЭКГ) в системы телемедицины как безопасное и удобное для пользователя решение. Быстрое расширение услуг телемедицины подчеркнуло необходимость надежных мер безопасности и персонализированного ухода за пациентами. Традиционные методы аутентификации, такие как пароли и PIN-коды, подвержены уязвимостям и часто не обеспечивают бесперебойного взаимодействия с пользователем. Исследование углубляется в технические аспекты получения сигнала ЭКГ, предварительной обработки, извлечения признаков и классификации, одновременно решая такие проблемы, как шум, изменчивость и совместимость устройств.*

Ключевые слова*: биометрия ЭКГ, безопасность телемедицины, биометрическая аутентификация, персонализация здравоохранения, обработка сигналов, идентификация пациентов.*

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ENHANCING TELEHEALTH SECURITY AND PERSONALIZATION THROUGH ECG BIOMETRICS: A COMPREHENSIVE ANALYSIS

***Abstract**: this paper explores the integration of electrocardio-gram (ECG) biometrics into telehealth systems as a secure and user-friendly solu-tion. The rapid expansion of telehealth services has underscored the need for robust se-curity measures and personalized patient care. Traditional authentication methods, such as passwords and PINs, are prone to vulnerabilities and often fail to provide a seamless user experience. The study delves into the technical aspects of ECG signal acquisition, preprocessing, feature extraction, and classification, while addressing challenges such as noise, variability, and device interoperability.*

***Keywords**: ECG biometrics, telehealth security, biometric authentication, healthcare personalization, signal processing, patient identification.*

Introduction.

Telehealth has emerged as a transformative solution in modern healthcare, enabling remote consultations, continuous monitoring, and timely interventions [1]. However, the increasing reliance on digital platforms has also exposed telehealth systems to cybersecurity threats and identity fraud. Conventional authentication methods, such as passwords and tokens, are not only susceptible to breaches but also create friction in the user experience. To address these limitations, biometric technologies have gained attention due to their ability to provide secure and seamless authentication. Among various biometric modalities, electrocardiogram (ECG) signals stand out for their uniqueness, universality, and resistance to spoofing [2]. This paper investigates the potential of ECG biometrics in enhancing telehealth security and personalization, offering a comprehensive analysis of its technical foundations, implementation challenges, and practical applications.

Technical Foundations of ECG Biometrics.

The human heart generates electrical signals that can be captured using ECG sensors. These signals exhibit distinct patterns influenced by factors such as heart rate, cardiac morphology, and physiological conditions [3]. The uniqueness of ECG waveforms makes them suitable for biometric identification. The process of utilizing ECG for authentication involves several stages, including signal acquisition, preprocessing, feature extraction, and classification. Signal acquisition requires high-quality sensors capable of capturing ECG data with minimal noise. Preprocessing techniques, such as filtering and normalization, are applied to remove artifacts caused by motion or environmental interference [4]. Feature extraction focuses on identifying key characteristics of the ECG waveform, such as the P-wave, QRS complex, and T-wave. Machine learning algorithms, including support vector machines and deep neural networks, are then employed to classify the extracted features and verify the user's identity [5].

To illustrate the workflow of an ECG-based authentication system, Figure 1 presents a horizontal layout of the architecture.

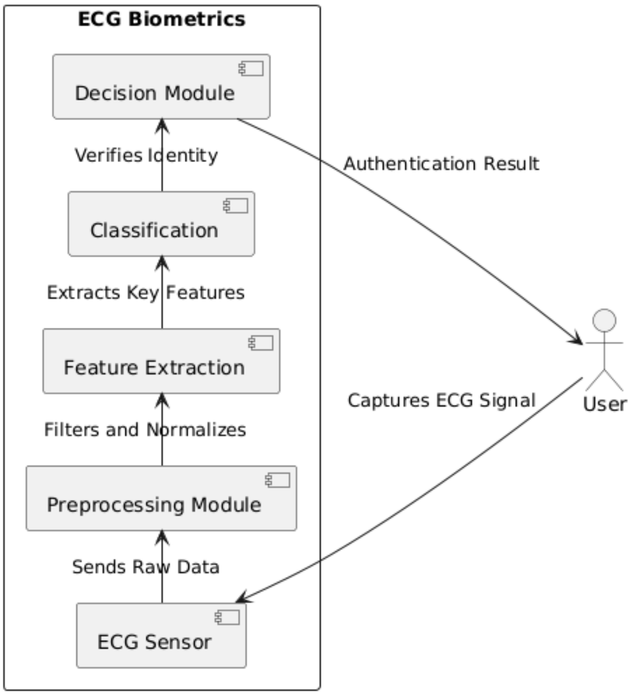

Figure 1. A diagram of the various applications.

Challenges in Implementing ECG Biometrics.

Despite its promising potential, the adoption of ECG biometrics in telehealth faces several challenges. Variability in ECG signals due to factors such as stress, physical activity, and electrode placement can affect recognition accuracy [6]. Ensuring interoperability across different devices and platforms is another critical concern, as telehealth systems often rely on diverse hardware configurations [7]. Additionally, the computational complexity of real-time signal processing may pose limitations on resource-constrained devices. Privacy and ethical considerations also warrant attention, as the storage and transmission of sensitive biometric data must comply with regulatory standards [8]. Addressing these challenges requires a multidisciplinary approach, combining advancements in signal processing, machine learning, and cybersecurity.

Applications of ECG Biometrics in Telehealth.

The integration of ECG biometrics into telehealth systems opens up a wide range of applications. One prominent use case is patient identification, where ECG signals serve as a unique identifier to ensure that the correct medical records are accessed during consultations [9]. Continuous monitoring is another valuable application, enabling real-time tracking of a patient's cardiac health and early detection of anomalies. ECG biometrics can also enhance fraud prevention by verifying the identity of users accessing telehealth services, thereby reducing the risk of unauthorized access [10]. Moreover, the liveness detection capability of ECG signals ensures that only living individuals can authenticate, mitigating the threat of spoofing attacks [11].

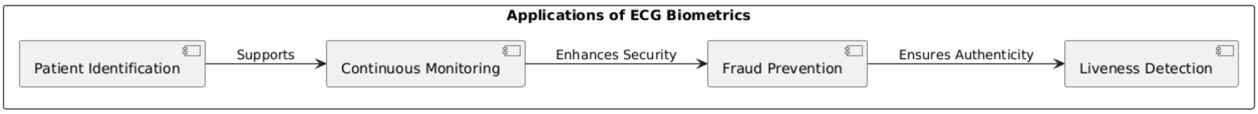

Figure 2. A diagram of the various applications.

Conclusion.

The integration of ECG biometrics into telehealth systems represents a significant step toward enhancing security and personalization in digital healthcare. By leveraging the unique properties of ECG signals, telehealth platforms can achieve robust authentication, continuous monitoring, and fraud prevention. While challenges remain, ongoing advancements in technology and research are likely to overcome these obstacles, paving the way for widespread adoption. As telehealth continues to evolve, ECG biometrics will play an increasingly vital role in shaping the future of secure and personalized healthcare.

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