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**Rancang Bangun Sistem Pengukuran dan Peringatan Dini Laju Denyut Jantung dengan Threshold Personal
Berbasis Heart Rate Reserve Menggunakan Sensor MAX30102**
Meitha Eka Nurhasanah, Dr. Eko Sulistyo, M.Si.
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INTISARI

RANCANG BANGUN SISTEM PENGUKURAN DAN PERINGATAN DINI LAJU DENYUT JANTUNG DENGAN *THRESHOLD* PERSONAL BERBASIS *HEART RATE RESERVE* MENGGUNAKAN SENSOR MAX30102

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Penelitian ini merancang dan membangun sistem pengukuran dan peringatan dini laju denyut jantung dengan *threshold personal* berbasis *Heart Rate Reserve* (HRR) menggunakan sensor MAX30102 dan mikrokontroler Arduino Nano. Sistem bekerja berdasarkan prinsip *photoplethysmography* (PPG) dan Hukum Beer–Lambert untuk mendeteksi perubahan volume darah secara non-invasif dan menghasilkan nilai *heart rate* dalam satuan *beats per minute* (BPM) secara *real-time*. Nilai *resting heart rate* (RHR) pengguna diukur pada kondisi istirahat sebagai *baseline* fisiologis individu, kemudian digunakan bersama HRmax untuk menghitung HRR menggunakan metode Karvonen. *Threshold* peringatan ditetapkan pada 50% HRR sebagai batas bawah dan 85% HRR sebagai batas atas mengacu pada pedoman American Heart Association (2024), dengan peringatan diberikan melalui buzzer dan LED ketika HR melampaui batas atas. Data hasil pengukuran dicatat secara otomatis ke Microsoft Excel menggunakan perangkat lunak Parallax PLX-DAQ. Pengujian fungsional dilakukan pada lima partisipan dewasa sehat berusia 22–24 tahun sebagai *proof of concept*. Nilai RHR kelima partisipan berada pada rentang 70,6–83,7 bpm dengan rata-rata BPM pengukuran berkisar 68,13–83,91 bpm dan standar deviasi 5,31–19,00 bpm. *Threshold personal* yang dihasilkan berbeda untuk setiap partisipan dengan batas bawah 134,3–140,9 bpm dan batas atas 178,9–180,9 bpm, membuktikan bahwa metode HRR menghasilkan batas yang lebih personal dibandingkan pendekatan berbasis HRmax semata. Selama pengujian pada kondisi istirahat, seluruh nilai BPM berada di bawah batas bawah *threshold* sehingga mekanisme peringatan tidak teraktivasi, namun sistem telah berfungsi sesuai logika yang dirancang. Sistem yang dikembangkan berhasil membuktikan bahwa pendekatan *threshold personal* berbasis HRR mampu menghasilkan batas peringatan yang lebih relevan secara fisiologis bagi masing-masing individu.

Kata kunci: detak jantung, *resting heart rate, heart rate reserve, photoplethysmography,* MAX30102

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ABSTRACT

DESIGN AND DEVELOPMENT OF A HEART RATE MEASUREMENT AND EARLY WARNING SYSTEM WITH PERSONALIZED THRESHOLDS BASED ON HEART RATE RESERVE USING THE MAX30102 SENSOR

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This study designed and developed a heart rate measurement and early warning system with personalized thresholds based on the Heart Rate Reserve (HRR) method using the MAX30102 sensor and an Arduino Nano microcontroller. The system operates based on the principles of photoplethysmography (PPG) and the Beer–Lambert Law to non-invasively detect changes in blood volume and measure heart rate in beats per minute (BPM) in real time. The user's resting heart rate (RHR) was measured under resting conditions as an individual physiological baseline and subsequently combined with the estimated maximum heart rate (HRmax) to calculate HRR using the Karvonen method. The warning thresholds were set at 50% HRR as the lower limit and 85% HRR as the upper limit in accordance with the American Heart Association (2024) guidelines, with warnings delivered through a buzzer and an LED when the heart rate exceeded the upper threshold. Measurement data were automatically recorded in Microsoft Excel using the Parallax PLX-DAQ software. Functional testing was conducted on five healthy adult participants aged 22–24 years as a proof of concept. The participants' RHR values ranged from 70.6 to 83.7 bpm, while the average measured heart rate ranged from 68.13 to 83.91 bpm with standard deviations between 5.31 and 19.00 bpm. The personalized thresholds differed among participants, with lower thresholds ranging from 134.3 to 140.9 bpm and upper thresholds ranging from 178.9 to 180.9 bpm, demonstrating that the HRR method generated individualized heart rate thresholds beyond those determined solely by HRmax. During resting-condition testing, all measured heart rate values remained below the lower threshold; therefore, the warning mechanism was not activated, although the system functioned according to the designed logic. The developed system successfully demonstrated that an HRR-based personalized threshold approach can generate heart rate warning limits that are more physiologically individualized for each user.

Keywords: *heart rate, resting heart rate, heart rate reserve, photoplethysmography, MAX30102*